APPENDIX A
SYNTHESIS OF AVAILABLE PHASE I SITE CHARACTERIZATION DATA FOR THE BURGER PROSPECT

EMP Plan of Study

Shell Outer Continental Shelf Lease
Chukchi Sea, Alaska

September 2014

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INTRODUCTION

The environmental monitoring program plan of study (EMP) is designed to meet the goals, objectives, and other requirements of U.S. Environmental Protection Agency (EPA) *Authorization to Discharge under the National Pollutant Discharge Elimination System (NPDES) for Oil and Gas Exploration Facilities on the Outer Continental Shelf (OCS) in the Chukchi Sea, permit number AKG-28-8100* (hereafter referred to as Permit No.: AKG-28-8100). The EMP is implemented using a four phased approach, however this document focuses on Phase I only. For information on the other phases, see the EMP. The purpose of Phase I is to establish a baseline site characterization for proposed drilling sites. This characterization is intended to address very specific data quality objectives organized into four elements:

1. Conduct an initial site physical sea bottom survey (including both a physical and visual characterization) to ensure that the drilling site is not located in or near a sensitive biological area or habitat [see Permit Sections II.A.13.b.1, II.A.13.f.1, II.A.13.j.2];
2. Collect oceanographic information (e.g., surface winds, currents, sea water temperature, salinity, turbidity) in order to characterize the physical conditions of the drill site [see Permit Sections II.A.13.b.2, II.A.13.f.2];
3. Collect chemistry data on natural parameters (e.g., dissolved metals, pH, total suspended solids) and potential contaminant parameters (e.g., metal contaminants of concern, total aromatic hydrocarbons, total aqueous hydrocarbons) in order to characterize the receiving water chemistry [see Permit Sections II.A.13.b.3, II.A.13.f.3]; and
4. Describe the composition of the drilling site's benthic community, including infaunal and epifaunal invertebrates, bivalves, and crustaceans [see Permit Sections II.A.13.b.4, II.A.13.f.4].

Since Shell is requesting authorization to discharge water-based drilling fluids and drill-cuttings (D001), there is an additional baseline data requirement in Phase I of certain sediment characteristics (e.g., chemistry, grain size, and contaminant concentrations) and bioaccumulation data (i.e., baseline concentrations of contaminants associated with Discharge 001 in benthic and epibenthic invertebrate tissue) as per Part II.A.13.j.2 and II.A.13.j.3, respectively, of Permit No.: AKG-28-8100.

As provided for in Permit No.: AKG-28-8100, the Phase I baseline requirements may be fulfilled by submitting site characterization data collected recently and at or within the vicinity of the proposed drill site locations to EPA for consideration.

Permit No.: AKG-28-8100 Section II.A.13.f

Phase I Assessment – Physical site characterization data, collected by the permittee pursuant to other agency requirements or as voluntary actions, if collected within the most recent five-year period at or in the vicinity of the drill site location, may be submitted to EPA for consideration of meeting the Phase I data collection requirements. The permittee must submit the existing data along with the EMP Plan of Study.

The purpose of this document is to provide a summary and synthesis of the recent site characterization data available for the proposed lease block locations within the Burger Prospect and demonstrate that the Phase I data collection requirements have been achieved for the Prospect. This document summarizes the types of data collected and the number and location of stations. In addition, the results from multiple years and locations are synthesized so that the existing physical and benthic biological conditions, including spatial and temporal variation prior to drilling activities, are clearly described.

Site characterization data in the past five years for the northeastern Chukchi Sea have been collected by two large, multi-year baseline studies programs and a smaller-scale, spatially intensive sampling effort conducted by Shell in 2012. Information about these programs is provided below.

Chukchi Offshore Monitoring in Drilling Area – Chemistry and Benthos Program

The Chukchi Offshore Monitoring in Drilling Area (COMIDA) (e.g., Trefry et al. 2012) program is a comprehensive program funded by the Bureau of Ocean Energy Management (BOEM) that is designed to establish an integrated knowledge of the Arctic marine ecosystem within the northeastern Chukchi Sea, and specifically, within the Planning Area designated for oil and gas exploration and development. The chemical and benthos (CAB) component addressed the benthic system with a particular emphasis on trophic structure, sediment chemical characteristics, inventories of anthropogenic chemicals (trace metals and organics), and inventories of benthic biota, both infaunal and epifaunal. The objectives included:

- To establish baseline data set for benthic infauna and epifauna, organic carbon and sediment grain size, radioisotopes for down core dating, as well as measure trace metals in sediments, biota and suspended particles; and
- To determine the sources, cycles and fate of carbon, selected trace metals and the role of trace metals on organic carbon dynamics and food web dynamics on the inner shelf of the Chukchi Sea

In 2009 and 2010, COMIDA CAB investigators collected water column hydrography, sediment cores for various chemical analyses and physical properties; water samples for total suspended solids, particulate organic carbon (POC), nutrients, and selected trace metals; benthic infaunal samples; epibenthic trawl samples, and biota (tissue) samples for chemical analyses (organic contaminants and metals) in the northeastern Chukchi Sea. The cruise reports, principal investigators' presentations, seafloor video footage, data models, links to data archive sites, and the May 2012 Final Report are all included on the program's website: www.comidacab.org.

Building from the success of the COMIDA CAB project, a new study began in 2012 with a focus on the Hanna Shoal region. The Hanna Shoal Ecosystem Study (Grebmeier et al. 2012) is a multi-disciplinary investigation to examine the biological, chemical and physical properties that define this ecosystem. The study extends the monitoring initiated under the COMIDA CAB program, in which over 70 stations were sampled in the northern Chukchi Sea. The Hanna Shoal study adds (1) a pelagic component to address standing stocks of phytoplankton and zooplankton and (2) a physical oceanographic study that addresses water mass movements through direct measurement of circulation, density fields, ice conditions and modeling (Grebmeier et al. 2012). In 2012, 73 distinct stations were occupied in the region. A similar number of stations were sampled in 2013. Once data have been collected, analyzed, and quality controlled, maps and other data products will be made publicly available on the project website indicated above.

Chukchi Sea Environmental Studies Program

The Chukchi Sea Environmental Studies Program (CSESP), begun in 2008, is a multi-year, multi-discipline marine science research program in the northeastern Chukchi Sea. The overall purpose of the program is to provide the industry partners the necessary baseline site characterization data that can be used to conduct realistic evaluations on the potential impacts of oil and gas activities. Importantly, it will also contribute to the overall knowledge of the northeastern Chukchi Sea marine ecosystem. The studies program has included various scientific disciplines over time including: physical oceanography, chemical oceanography, plankton ecology, benthic ecology (infaunal and epibenthic communities), seabird ecology, marine mammal ecology, pelagic and demersal fisheries, and bioacoustics.

In 2008 and 2009, the program consisted of two prospect-specific Study Areas for ConocoPhillips and Shell, and in 2010, an additional prospect-specific Study Area was added for Statoil USA. The Study Areas, each consisting of a 900 square nautical mile area, are designated as Klondike, Burger and Statoil. The summary information and synthesis included in this document are primarily derived from work conducted within the Burger Study Area. In 2011, the studies program expanded to a larger area that encompassed the three prospect-specific Study Areas and Hanna Shoal to the north..

Details about the science and the investigators as well as maps, presentations, and final reports are available through the program website at: www.chukchiscience.com. A special issue of the journal Continental Shelf Research was published in September, 2013 entitled Seasonal and interannual dynamics of the northeastern Chukchi Sea Ecosystem (Continental Shelf Research 67:1-166). The issue focuses on the ecology of the northeastern Chukchi Sea and synthesizes information across the first 3 years of the study program (2008 – 2010) for each discipline and for the broader-scale Chukchi Sea ecosystem.

Shell Discharge Monitoring Program

In 2012, additional site characterization data were collected by Shell at 18 localized stations in the Burger Prospect as part of a voluntary discharge monitoring program (DMP) conducted by Shell prior to implementation of Permit No.: AKG-28-8100. Unlike other scientific programs conducted in the area, the DMP stations were distributed within a tight grid extending from 25 meters (m) to 1500m from the Burger A drill site.

All of the sampling locations within the Burger Prospect, from which sediment characteristic and benthic ecology data have been collected during these programs, are illustrated on Figure 1. Sample stations in the immediate vicinity of the Burger Study Area are also included. Not shown are the locations of cruise tracks from which physical oceanographic data were collected.

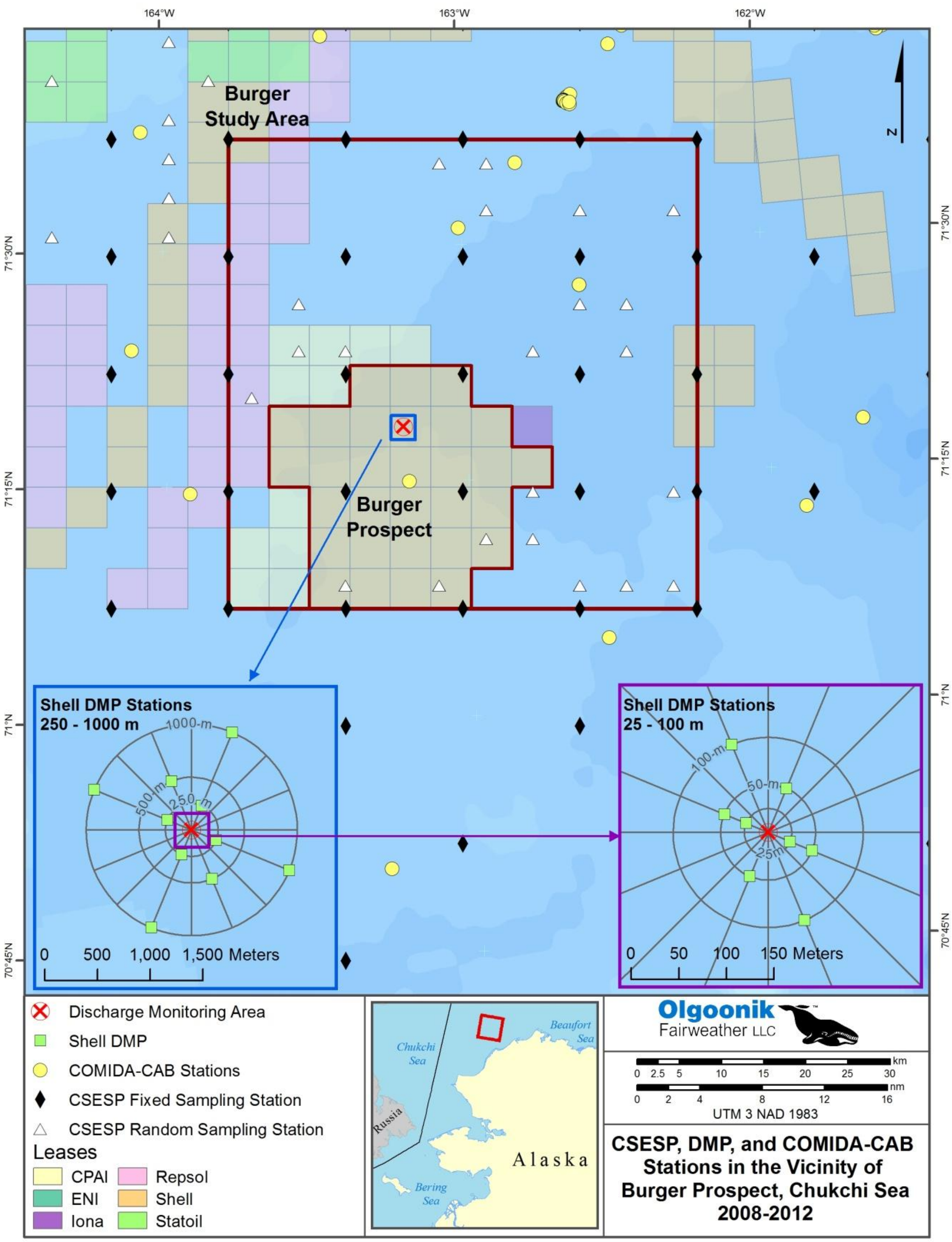


Figure 1: CSESP, DMP AND COMIDA CAB stations in the vicinity of Burger prospect, Chukchi Sea, 2008-2012.

The remainder of this document is organized to specifically address the four elements of Phase I:

- Section 1 summarizes the available digital videos, sediment-profile imaging (SPI) photographs, and other photographs and benthic ecology data that fulfills the requirements for an initial site physical sea-bottom survey;
- Section 2 summarizes physical oceanographic and sediment characterization data collected over the past five years and synthesizes this information into a concise description of the oceanographic and seafloor conditions within the northeastern Chukchi Sea region and at the Burger Prospect location;
- Section 3 summarizes available receiving water chemistry analytical results and specifically addresses the following parameters: dissolved metals, pH, total suspended solids and TAH and TAqH; and
- Section 4 provides a synthesis of extensive site characterization data specific to benthic ecology at the Burger Prospect area and a discussion of several recent efforts to establish baseline bioaccumulation data in benthic marine organisms.

1. INITIAL SITE PHYSICAL SEA BOTTOM SURVEY

Permit No.: AKG-28-8100 Section II.A.13.f.1

Initial Site Physical Sea Bottom Survey. Conduct an assessment of the physical sea bottom before initiating discharges authorized by the general permit to ensure the drilling site is not located in or near a sensitive biological area or habitat. The survey should provide both a physical and visual characterization of the seafloor. If the proposed initial site is located in a sensitive biological area or habitat, the permittee must find another well location and report the information to the Director in accordance with Section II.A.13.k.1.

The purpose of this section is to demonstrate that the proposed Burger Prospect drilling sites are not located in or near a sensitive biological area or habitat. Supporting information and available visible characterization data are presented.

Numerous intensive and broad-scaled benthic surveys have been conducted throughout the northeastern Chukchi Sea from the 1960s to the present. At this time, the only areas in Arctic Alaska's marine environment known to have sensitive biological habitat (i.e., particularly susceptible to impact or damage) are located where hard strata (boulders) predominate. These boulder patches are believed to have been deposited on the seafloor long ago (Dunton et al. 2009) and provide the foundation for a unique Arctic kelp ecosystem (Martin and Galloway 1994). For example, in Stefansson Sound (east of Prudhoe Bay) in the Beaufort Sea, patches of pebbles, cobbles, and boulders at cover densities of 10 to 25% have been intensively studied since the 1970s. In this area, known as the Boulder Patch, a variety of brown and red macroalgae have colonized the boulders forming one of the few known macroalgal beds along the Alaskan Arctic coast. Sessile fauna such as sponges, encrusting bryozoans, hydroids, soft corals, and tube worms thrive on the rocks and on macroalgal substrates (Dunton et al. 2009). This three-dimensionally structured, epilithic community provides a very unique Arctic marine habitat for a number of associated macro-organisms, including more than 150 species of macroalgae, invertebrates and fishes (Martin and Galloway 1994, Dunton et al. 2009) compared to 20 to 30 infaunal species (mainly polychaetes and amphipods) reported in surrounding areas. The Boulder Patch is a unique area of high biodiversity in an otherwise silt-mud dominated system that is devoid of the majority of these diverse faunal and floral groups (Martin and Galloway 1994).

In the northeastern Chukchi Sea, similar boulder patches have never been reported. Pre-drilling bathymetric and shallow hazard surveys have been conducted within the Burger Prospect and at specific proposed drill sites (in compliance with BOEM exploratory drilling requirements); the results of these surveys are presented in the Chukchi Sea Exploration Plan (Shell 2012). These surveys have not detected cobbles or boulders on the surface of the seafloor at a density that might indicate the possibility of a "boulder patch" benthic habitat.

In addition, digital videos, sediment-profile imaging (SPI) profile photographs, plan-view photographs, and benthic-ecology assessment data that were collected between 2008 and 2012 under the CSESP and Shell DMP also confirm that there are no "sensitive biological areas or habitats" that could be designated as critical or unique in the Burger prospect.

Plan-view and cross-sectional digital images and data collected in early August 2012 using SPI equipment are presented in the *Burger A Pre-Drill Sediment Profile Imagine Survey (April 2013)* (and included as Attachment A of this Appendix). As discussed in Section 4.0 (Survey Results) of this report, examination of the photographs indicates consistent conditions in surface sediments throughout the Burger A survey area. Sediments at all survey stations appeared to be uniformly fine sand-silt-clay. Sediment compaction, as indicated by prism penetration depth, was uniform throughout the survey area. Plan-view camera images provided information regarding the sea bottom surface and associated benthic organisms. The dominant epifaunal taxon was the ophiuroid brittle star (ranging from 11 individuals/m^2 to 355 individuals/ m^2). Although turbid water (caused by storms) resulted in reduced visibility in certain instances, the images acquired in 2012 document conditions that are very similar to those from 2011. Video and plan-view images from the Burger Study Area, collected in 2011 using a camera sled (Figure 2) and in 2012 using the SPI equipment (Figure 3), indicate fine-grained, muddy sediments with the surface dominated by the brittle star *Ophiura sarsi*, a brittle star with a broad circumpolar distribution (Bluhm et al. 2009).

SPI profile photographs depict an upper layer of light tan-colored sediment indicating biologically-active infauna (invertebrate animals residing within the sediments) and darker sediments below with tube-dwelling infauna. In particular, it appears that the survey area has well developed and mature infaunal communities – a finding that is consistent with many years of benthic sampling within the Burger Study Area. Thus the SPI photographs confirm a depositional environment and benthic habitat conditions expected for this part of the northeastern Chukchi Sea.

Certain news releases in 2012 suggested that sensitive species, specifically soft corals, were newly discovered in the Burger Study Area and represented a critical habitat at the drilling locations (see http://www.greenpeace.org/usa/en/media-center/news-releases/Abundant-corals-discovered-at-Shells-Chukchi-drill site). The soft coral in question, the Sea Raspberry (*Gersemia fruticosa* and *G. rubiformis*), is well-known and widely dispersed throughout the north Pacific, the Bering Sea, Alaska's coastal waters, and the Chukchi Sea. Based on the extensive CSESP sampling efforts from 2008 to 2012, there do not appear to be any habitats or species that can be designated as critical or unique in the Burger Study Area or at the Burger Prospect.

In summary, the information presented in this section supports Shell's conclusion that there are no known sensitive biological habitats or areas in the Burger Prospect area and that the information collected to date fulfills the requirement for an initial site physical sea-bottom survey at the proposed Burger Prospect drill sites.

Figure 2: Digital still photographs (showing an area 50cm x 28cm or 0.14 m^{-2}) extracted from videos taken during 2011 in the Burger Study Area. The red dots are 10 cm apart.

Figure 3: Digital images taken in 2012 from the Burger A drill site in 2012 using SPI equipment. The red dots (enhanced) are 10 cm apart. Source: Battelle, 2012, Attachment A.

2. PHYSICAL CHARACTERISTICS

Permit No.: AKG-28-8100 Section II.A.13.f.2

Physical Characteristics. Collect physical data to characterize the conditions of the drilling site and receiving waters. These physical data include surface wind speed and direction, current speed and direction throughout the water column, water temperature, salinity, depth, and turbidity.

The purpose of this section is to summarize the available physical oceanographic and sediment characterization data and synthesize this information into a concise description of the conditions at the drill sites and receiving waters. The regional oceanography of the northeastern Chukchi Sea is presented first and then specific information about the physical characteristics at the Burger Prospect is provided.

2.1. Regional Oceanographic Conditions

The basic physical oceanographic conditions of the northeastern Chukchi Sea are well-known because of a variety of year-long, subsurface oceanographic moorings that began in the 1980s and numerous shipboard measurements collected over many years (Weingartner 1998, 2005, 2013). It is generally accepted that North Pacific Ocean waters are transported through the Bering Strait, across the Chukchi continental shelf and into the Arctic Ocean. This circulation is primarily driven by water flowing "downhill" from the higher sea level in the Pacific Ocean to the lower sea level in the Arctic Ocean.

Although relatively shallow (40 to 50 m deep), the general northward flow of water does not proceed uniformly across the Chukchi continental shelf because distinctive shelf features "guide" the flow and the distribution of water masses (Figure 4). These features include Herald Shoal, located in the center of the shelf, with a diameter of about 100 km and minimum depths of about 20 m, a relatively shallow north-south oriented depression called the Central Channel, and Hanna Shoal, about 100 km long and 75 km wide, with minimum depths of about 25 m.

Figure 4: Distinctive shelf features of the Chukchi continental shelf.

Multiple past investigations have demonstrated that the flow of ocean water occurs along three main branches – each associated with a particular bathymetric feature (Figures 4 and 5). The first branch is composed of flows occurring northward through the Bering Strait and continuing northwestward through Hope Valley and into Herald Valley. While most of this outflow continues to the shelf break, some of it may spread onto the shelf north of Herald Shoal and drift eastward toward the central shelf (Weingartner 1998, 2005, Day et al. 2013).

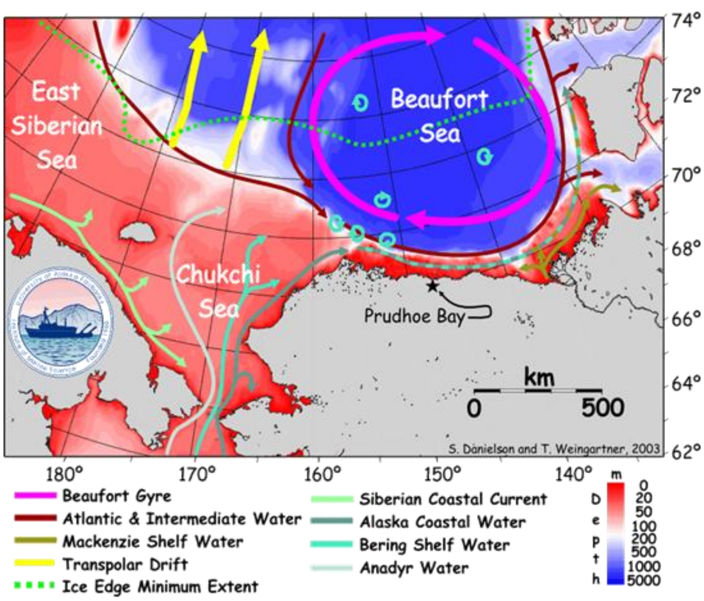


Figure 5: Flow of ocean water in the East Siberian Sea, northeastern Chukchi Sea, and Beaufort Sea.

The second branch flows northeastward along the Alaskan coast towards Barrow Canyon. In the summer, this flow includes the northward extension of the low-salinity and nutrient poor Alaskan Coastal Current flowing through the Bering Strait. The Alaskan Coastal Current begins in British Columbia, Canada and southeastern Alaska as freshwater runoff discharges into the sea. Due to the Earth's rotation, this discharge is forced west and north traveling along Alaska's coast through the Gulf of Alaska, Bering Sea and eventually into the Chukchi and Beaufort Seas. The current maintains its low salinity, warmth, and nutrient-poor characteristics as warmer river discharges are incorporated. At Barrow Canyon, the Alaskan Coastal Current merges with waters flowing eastward from the central Chukchi shelf while proceeding down the Canyon toward the shelf break (Day et al. 2013).

A third branch, of moderate salinity and nutrient load, flows northward through the Central Channel. Some of this water moves eastward along the south side of the Burger Prospect and eventually enters Barrow Canyon, while another fraction continues northward toward the outer shelf west of Hanna Shoal (Day et al. 2013).

The nutrient and organic carbon loads carried along these branches differ. In the summer, the Herald Valley outflow is saltier, colder, and richer in nutrients and marine-derived carbon than the waters transported in the Alaskan Coastal Current along the Alaskan coast. The properties of the waters crossing the central shelf, including the Burger Prospect discussed below, fall between these extremes.

In addition to Pacific Ocean water, there are three distinct water masses that form seasonally or intrude occasionally in the northeastern Chukchi Sea, including the Burger Prospect area. These are the (1) sea ice meltwater pools, (2) upwelled continental slope waters, and (3) water masses that originate as a result of the formation of recurring polynyas.

The first water mass consists of the meltwaters produced as sea ice melts and/or retreats across the shelf from summer through fall. These are relatively cold but low-salinity waters, having much lower density than the cold, saline deeper waters remaining from winter or the relatively warm Pacific waters transported northward from Bering Strait in the summer. Meltwater masses form 10 to 20 m thick, heavily stratified pools that are separated from ambient shelf waters by 10 to 20 km wide fronts. These pools and fronts are prominent along the perimeter of the ice edge. They may remain at both Hanna and Herald Shoals for several weeks after ice has disappeared due to the relatively weak circulation atop the shoals. The weak circulation atop the shoals also results in greater amounts of ungrazed plankton material falling onto the shoal and surrounding area, which in turn supports an abundance of clams and other benthic organisms. Not surprisingly, the residual sea ice that persists in the vicinity of Hanna Shoal is used by Pacific walrus to haulout while feeding on the rich benthic fauna present.

The second water mass consists of upwelled continental slope waters that occasionally intrude onto the northeast Chukchi continental shelf through Barrow Canyon. These are upwelled into the Canyon from depths of 150 m or greater, most frequently in fall and winter during strong northeasterly wind events. On occasion, the upwelled slope water includes deep (approximately 250 m) relatively warm, salty water whose original source was the Atlantic Ocean. Typically, these upwelling events last a few days before the upwelled water drains back down the Canyon.

Most of these events are confined to the Canyon proper, but on occasion continental slope water reaches the head of the Canyon and spills onto the Chukchi shelf.

The third distinct water mass originates as a result of the formation of recurring polynyas. Polynyas are open water areas surrounded by sea ice that form under freezing atmospheric conditions. The largest and most frequently formed polynyas develop in the Chukchi Sea along the northwest coast of Alaska during winter episodes of cold, offshore winds. The winds push sea ice offshore, allowing surface seawater to lose heat to the atmosphere. Since the seawater is already at the freezing point, cooling also results in rapid formation of new ice, which is continuously swept downwind by the wind so that the polynya remains open. Once the winds weaken sufficiently or reverse direction, the polynya freezes over. Although large volumes of ice can be produced in polynya, their development is episodic since it depends upon large-scale weather systems. The salinity (and density) of the waters within the polynya increases greatly because salt is expelled from newly forming ice crystals. The resulting cold, saline waters contribute significantly to the volume of winter water formed on the Chukchi shelf.

Although the annual temperature and salinity cycles between the Chukchi Sea and Bering Strait are very similar, the near bottom winter waters on the Chukchi continental shelf, including the Burger Prospect area, remain saline and close to the freezing point longer than those waters in more southern areas of the Chukchi Sea and the Bering Strait. In part, this is due to the longer freezing season, but it also reflects the time required for cold, saline deep waters moving northward from the Bering Sea to traverse the Chukchi continental shelf. Moreover, winter waters are replaced much more slowly around the Hanna Shoal region than along the main flow pathways (Weingartner et al. 2013).

Chukchi Sea waters are eventually flushed into the Arctic Basin and/or into the Alaskan Beaufort Sea. The low density Chukchi summer waters enter the upper 50 m of the Arctic Ocean basin, whereas denser winter waters typically descend to 100 to 200 m depth in the Arctic Basin. Here they contribute to the maintenance of the Arctic Ocean’s halocline, a salt-stratified layer that separates the fresh, cold surface (Weingartner et al. 2013).

In summary, circulation in the Chukchi Sea is controlled largely by the opposing tendencies between the pressure gradient that forces water northward though the Bering Strait and across the Chukchi continental shelf and the predominant wind systems that force water southward. The location of various branches of this northward flow of water is primarily due to the shelf topographic features such as the Central Channel and Hanna Shoal.

2.2. Burger Prospect Oceanographic Conditions

Physical data collected for the past five years in the OCS Chukchi Sea under the CSESP and COMIDA programs include surface wind speed and direction, current speed and direction throughout the water column, water temperature, salinity, depth and turbidity. Data collected from the northeastern Chukchi Sea over the past five years include shipboard measurements of vertical profiles of temperature and salinity, velocity measurements from year-round oceanographic moorings, satellite-tracked drifters, and shore-based surface current-mapping radars that are operating during the open-water season from August through late October. These data are supplemented by historical data sets (shipboard and moorings only) from the northeastern Chukchi Sea shelf. This information has been reported by Coachman et al. (1975), Martin and Drucker (1997), Weingartner et al. (1998, 2005, 2013), Winsor and Chapman (2004), Woodgate et al. (2005a, 2005b), Pickart et al. (2005), Spall (2007), Mudge et al. (2010), and Timmermans and Winsor (2013). In addition, several publicly-accessible websites provide additional information and data, some of which (e.g., meteorological reports, data from shore-based current-mapping radars, satellite drifters) provide data in real-time during the open-water season. These websites include:

- http://www.ims.uaf.edu/hfradar/ ;
- http://dm.sfos.uaf.edu/chukchi-beaufort/data/drifters/ ; and
- http://www.ims.uaf.edu/chukchi/ ;
- http://www.aoos.org/industry-arctic-data/.

2.2.1. Water Depth

Bathymetric data and individual sampling station data from both the CSESP and COMIDA CAB studies demonstrate that water depth is well characterized in the Chukchi Sea and within the Burger prospect. Water depths in the Burger prospect are shallow and consistently range from 40 to 50 m.

2.2.2. Temperature and Salinity

The temperature and salinity properties of the Chukchi shelf undergo seasonal transitions that are a consequence of freezing and thawing (largely governed by the annual cycle in solar radiation) and transport of water masses northward from the Bering Sea. In the summer and fall months, Bering Sea summer waters are an important source of heat that accelerates ice retreat (in summer) and delays fall ice formation. By the end of the winter, water column temperatures are vertically and nearly horizontally uniform at the freezing point of seawater (approximately −1.7 degrees centigrade [°C]). Salinity also is vertically uniform at this time and ranges from 32 to 33 parts per thousand (ppt). By early summer, these dense waters, all of which were formed during the previous winter, are found across the entire northeastern Chukchi shelf. As ice-melt begins in spring, the water column stratifies because the surface layer is diluted by fresh ice meltwater that is less dense than the salty bottom waters. Depending on mixing and the rate of ice-melt, the upper 5-15 meters (m) of the water column has salinities between 27 and 30 ppt. Spring and mid-summer surface temperatures can range from approximately −1°C to approximately +4°C, with the warming largely being a consequence of solar warming of the meltwater. Through July, much of the northeastern Chukchi shelf, and the Burger Study Area in particular, is characterized by a strongly salt-stratified water column. By August, the stratification of the northeastern Chukchi shelf weakens with the arrival of less stratified, moderately salty, and warm waters from the Bering Sea. These waters infiltrate the Burger Study Area from the west and south, leading to a reduction in stratification as surface meltwaters and dense winter bottom waters gradually are displaced from the region. Within the Burger Study Area, the replacement of these water masses typically is completed by mid- to late September. The erosion in stratification also is accelerated in fall as wind speeds increase (generally) and solar heating diminishes, and the water column typically is well-mixed again by mid-October. An example of the August-September transitions in water column temperature and salinity over the northeastern Chukchi Sea (including Burger prospect) is shown in Figure 6. Colors indicate different values for temperature and salinity. Warmer temperature values are indicated by yellow, orange, and red colors while cooler temperature values are indicated by light and dark blue colors. Similarly, higher salinity concentrations are indicated by yellow and orange colors and lower salinity concentrations are indicated by green and blue colors.

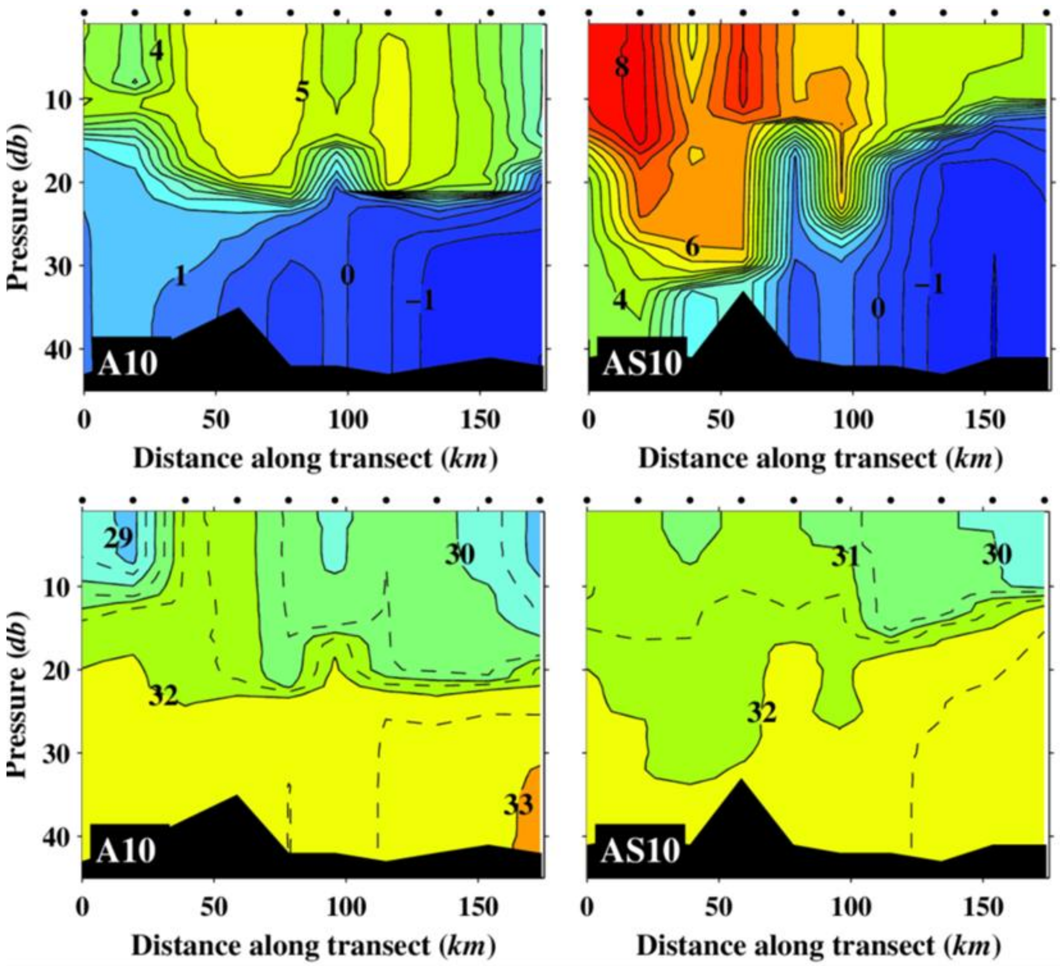


Figure 6: Temperature (top) and salinity (bottom) cross-sections across the northeastern Chukchi Sea in early August (A10; left) and late August to mid-September (AS10; right), 2010 (e.g., Weingartner et al. 2013). Colors indicate different values for temperature and salinity. Warmer temperature values are indicated by yellow, orange, and red colors while cooler temperature values are indicated by light and dark blue colors. Similarly, higher salinity concentrations are indicated by yellow and orange colors and lower salinity concentrations are indicated by green and blue colors.

2.2.3. Currents and Wind

Although a large-scale forcing factor drives water flow northward, this flow is against the predominant northeast surface winds that tend to force water flow to the southwest. Therefore, temporal variations in current strength and direction can be significant – especially in the presence of strong winds. Sufficiently strong storms can reverse the flow to the southwest over broad portions of the shelf, including the Bering Strait region. The wind influence is greatest, however, at the surface and decays rapidly with depth so that currents may vary in magnitude and direction with depth. Under moderate to strong winds, the surface waters are expected to move downwind while the sub-surface flow would weaken – but still flow upwind.

At the Burger Prospect, mean current speeds during the ice-free season range between 5 and 10 centimeters (cm) per second (s^{-1})(0.1-0.2 knots [kt]) and generally flow toward the east. The variability of the current strength is related primarily to variations in the strength and direction of the winds. On average, winds blow from the eastern (northeast, east or southeast) octants about 45% of the time in July, with this percentage increasing to 60% in October (Figure 7).

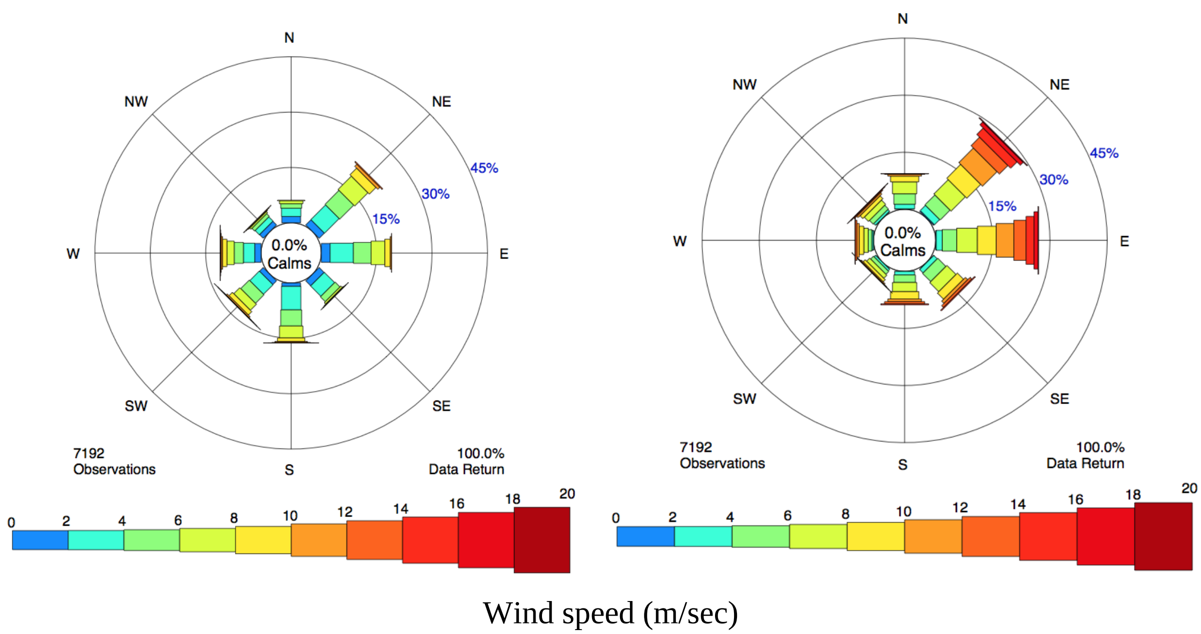


Figure 7: Wind roses for July (left) and October (right) for the Northeast Chukchi Sea near the Burger Prospect. These distributions characterize the mean wind speeds and directions recorded at the beginning and end of the open water season, and show the predominant easterly direction and increase in wind speed observed throughout the open water season**.**

The frequency distributions of winds blowing from the other octants are roughly comparable in these months, with each octant accounting for 5 to 10% of the total. The existing data suggest that the flow begins to reverse (at least at the surface) when winds from the east or northeast exceed ~6 m s^{-1} (12 kt). Winds generally are weak during July and August, when <30% of the winds speeds from the eastward octants exceed 6 m s^{-1}. Hence, currents at the Burger Prospect tend to be comparable to the mean about 70% of the time during these months. In September and October, wind speeds exceeding 6 m s^{-1} occur about 35% of the time. This increase in wind strength is associated with an increase in current variability. Currents vary principally between being eastward and westward in the Burger prospect. As a consequence of fall storms, the mean flow conditions occur ~40-50% of the time in September and October. Maximal wind-driven current speeds are 40-50 cm s^{-1} (0.8-1.0 kt) and may persist for periods of two to several days. Although these larger currents may occur anytime during the open-water season, they are more common in the fall when stronger winds associated with fall storms move through the region. The velocity field also is highly correlated spatially over the northeastern Chukchi shelf. In general, there is little velocity difference (shear) between surface and subsurface layers of the water column. However, the magnitude of the velocity shear depends upon the strength of the stratification, in that strongly stratified waters tend to have greater shear because stratification traps the momentum imparted by the winds to the surface layers.

In conjunction with the existing data sets for the Chukchi Sea, shore-based radars operate throughout the open-water season. The current data generated from the shore-based radars includes data covering the Burger prospect. These data are publically available in real-time on the internet at http://www.ims.uaf.edu/hfradar/animation/.

2.2.4. Turbidity and Total Suspended Solids

Turbidity and total suspended solids (TSS) are measures of “particulate” concentrations in the water column. Turbidity is a measure of the “clarity” of water, while TSS is a discrete measurement of particulate concentration in a discrete water sample. The baseline data represent TSS data collected from discrete water samples in the Chukchi Sea and are presented here. Data from COMIDA CAB indicate that the concentrations of TSS in the upper 30 m of the water column for the combined 2009 and 2010 data set for the northeastern Chukchi Sea (n = 84) averaged 0.27 ± 0.18 (standard deviation [SD]) milligrams per liter (mg/L) with a range of 0.07 to 0.74 mg/L (Table 1). In the Burger Study Area, TSS values averaged 0.31 ± 0.23 mg/L and ranged from 0.13 to 0.38 mg/L, for water depths in the upper 30 m. In contrast, at water depths greater than 30 m, values for TSS in the northeastern Chukchi Sea during both 2009 and 2010 averaged 1.8 ± 0.8 (SD) mg/L, almost seven times higher than found in the upper water column (Table 1). In the Burger Study Area, TSS averaged 1.1 ± 0.57 mg/L and ranged from 0.73 to 1.54 mg/L for water depths greater than 30 m. Most vertical profiles for TSS show a clear trend of lower values in surface water and distinctly higher values below the pycnocline, in the lower 20 m of the water column. As previously mentioned, bottom currents in the eastern Chukchi Sea have an annual average flow of ~5 to 10 cm s^{-1} with maximal values as high as 45 cm s^{-1} (Weingartner et al. 2005), sufficient to re-suspend bottom sediments. A strong pycnocline and shear across that density boundary seem to confine re-suspended sediments to the bottom 20 m of the water column. Values for TSS in surface water also are limited by a minor influx of river runoff to the northeast Chukchi Sea.

Table 1: Summary data for total suspended solids collected from the Chukchi Sea during the 2009 and 2010 COMIDA surveys.

	2009	2010	2009	2010	2009	2010
	<30 m	<30 m	>30 m	>30 m	>30/<30 m	>30/<30 m
Total Suspended Solids (mg/L)						
Mean	0.29	0.26	2.41	1.55	8.4	5.9
SD	0.19	0.17	0.96	0.55	-	-
N	34	50	14	25	-	-

	2009	2010	2009	2010	2009	2010
	<30 m	<30 m	>30 m	>30 m	>30/<30 m	>30/<30 m
Max	0.69	0.74	4.29	2.47	-	-
Min	0.08	0.07	1.23	0.73	-	-

The composition of the suspended particles also was distinctly different in surface versus bottom water. For example, concentrations of particulate Al (as a % of TSS) averaged 1.0 ± 0.9% in the upper water column vs. 3.8 ± 1.8% for samples collected at greater than 30 m water depth during 2009 and 2010. This trend is consistent with greater amounts of re-suspended aluminosilicates (silt and clay minerals) in the lower water column relative to the upper water column. In contrast with the trend for particulate Al, concentrations of particulate organic carbon (POC) as a % of TSS for 2009 and 2010 combined averaged 19 ± 9% at water depths <30 m and 9 ± 7% at water depths >30 m (Table 1). Thus, more organic-rich and clay-poor particles were collected from the upper part of the water column and vice versa for the lower part of the water column.

2.3. Sediment Characteristics

Section II.A.13.j.2 of the Permit No.: AKG-28-8100 requires baseline data for sediment characteristics associated with authorization to discharge water-based drilling fluids and drill-cuttings. Baseline concentrations of potential contaminants in sediments are therefore needed to determine whether anthropogenic inputs of the contaminants are present in samples collected in Phase III or Phase IV field efforts. Because trace metals and hydrocarbons occur naturally in the environment at different concentrations, the process of establishing baseline values can be challenging. In this section, concentration data for metals and hydrocarbons in sediments are presented; analytical results from the larger northeastern Chukchi Sea region are presented first and then compared to the Burger Prospect specific results. This comparison is presented in order to demonstrate that useful baseline values already exist for the Burger Prospect area.

2.3.1. Metals

More than 300 sediment samples (studies described above) from the northeastern Chukchi Sea have been collected and analyzed for 19 metals. This data set includes 69 samples from the Burger Study Area (square marked B in Figure 8) and 259 samples from outside of the Burger Study Area, in the northeastern Chukchi Sea (Figure 9, Table 2). To place sample numbers in perspective, Table 2 provides an overall summary of sediment samples as well as environmental samples from other matrices (water and biota) collected and analyzed for metals in the Chukchi Sea. A five-fold range in concentrations of Al and other metals has been found throughout the northeastern Chukchi Sea (Figure 10A). However, because concentrations of Al are positively correlated with silt + clay content (i.e., concentrations of Al are very low in coarse-grained quartz sand and carbonate shell material and are much higher in fine-grained aluminosilicates), the relationship between absolute concentrations of Al and trace metals can be explained by variations in grain size, TOC and/or mineralogy because these three variables control metal concentrations in sediments (Trefry et al. 2003). This relationship can then be used to determine baseline metal concentrations in sediments from the northeast Chukchi Sea. The lowest concentrations of Al are found near the coast in sand and gravel and in the sandy sediments of Hanna Shoal. The highest concentrations of Al are found offshore in silt- and clay-rich sediments (Figures 9A and 9B). The distribution of fine-grained sediment (silt + clay) follows that observed for Al (Figure 10A) because fine-grained sediment contains Al-rich clays (i.e., aluminosilicates). Sediment concentrations of Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Sn, V and Zn also vary considerably throughout the northeastern Chukchi Sea; however, they are strongly correlated (r^2 = 0.7-0.9) or very strongly correlated (r > 0.9) with concentrations of Al (see Cr, Zn and Hg in Figures 9B, C and D) and thus followed the same geographic trends described for Al (Figure 10A).

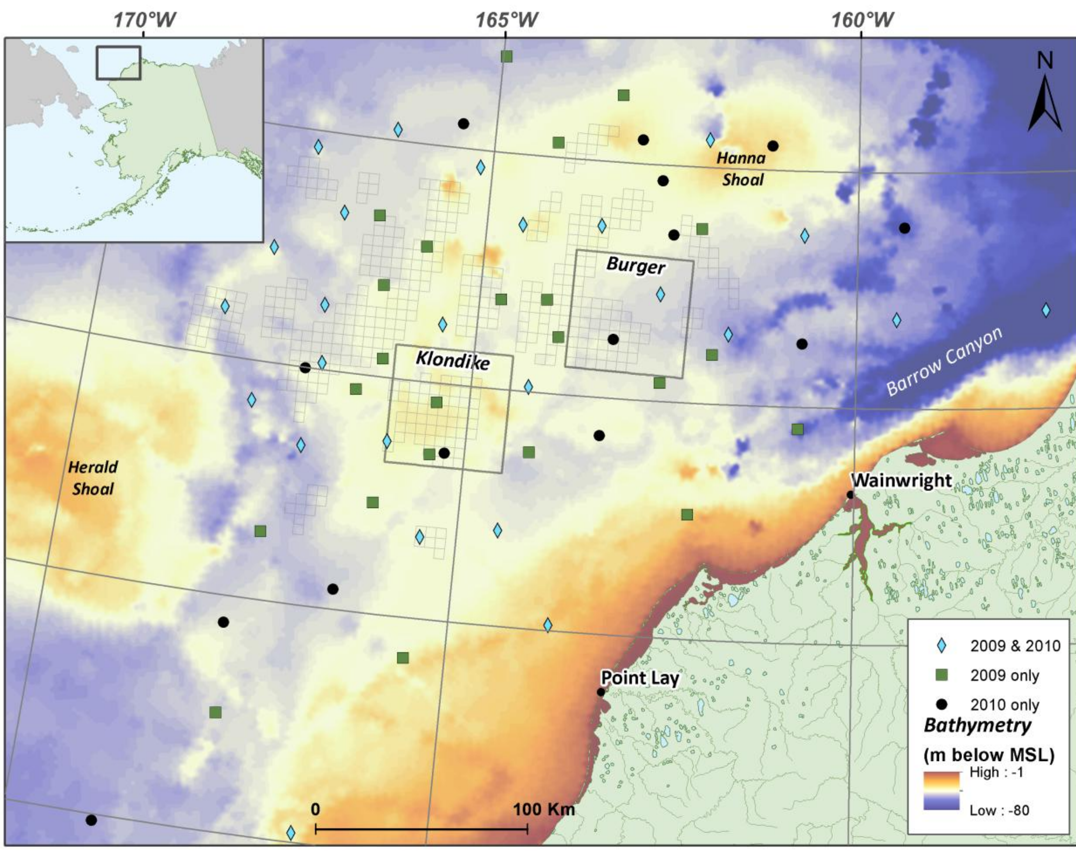


Figure 8: Location of sediment sampling stations in the northeastern Chukchi Sea. The stations identified with markers were sampled as part of the COMIDA project (Dunton et al. 2012). The two squares identify the Burger (B) and Klondike (K) Study Areas.

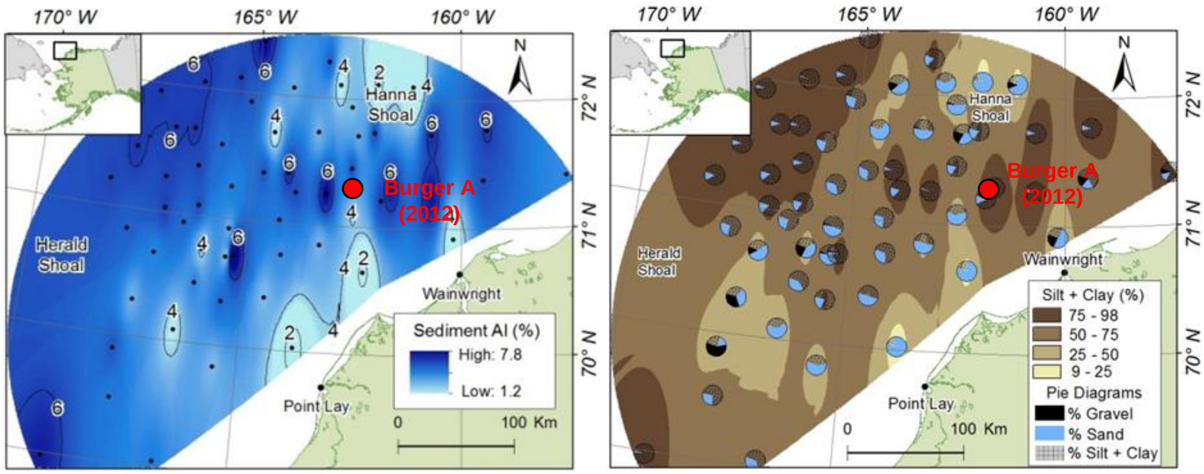


Figure 9: Contour maps for (A) concentrations of aluminum (%), and (B) % silt + clay with pie diagrams showing gravel (black), sand (blue) and silt + clay (cross-hatched) in surface sediments. Solid circles show the 58 stations that were used to determine baseline metal concentrations in sediments from the northeast Chukchi Sea (Trefry et al. 2012). Red circle shows location of the Burger A drill site.

Table 2: Summary of sediment, biota, and water samples collected in the northeastern Chukchi Sea for metals analysis, including the 2012 Burger A drill site.

Area	Year Collected	# Surface Sediment Samples	# Samples from Cores (# cores)	# Pools of Clam Samples (*Astarte* spp.)	# Water Samples (filtered)
NE Chukchi Sea					
Burger A drill site	2012	18	-	17	-
Burger Study Area	2008-2010	46	23 (3)	17	6
Northeastern Chukchi Sea	2009-2012	76	183 (12)	5	88

A reliable and well-accepted method for identifying background metal concentrations in marine sediments has been developed – by normalizing trace metal concentrations to Al concentrations, the most abundant metal in marine sediments (Bruland et al. 1974; Trefry and Presley 1976; Schropp et al. 1990; Trefry et al. 2003). This is based on the assumption that, without detectable anthropogenic inputs, natural concentrations of metals will plot within the 99% prediction intervals (calculated from linear regression analysis), as shown on plots of individual metals versus Al concentrations (see Figures 9B, 9C, 9D). The prediction intervals on the various metals versus Al plots define the upper and lower limits of baseline metal concentrations and can therefore be used to define baseline metal concentrations throughout the northeastern Chukchi Sea, including the Burger Prospect area.

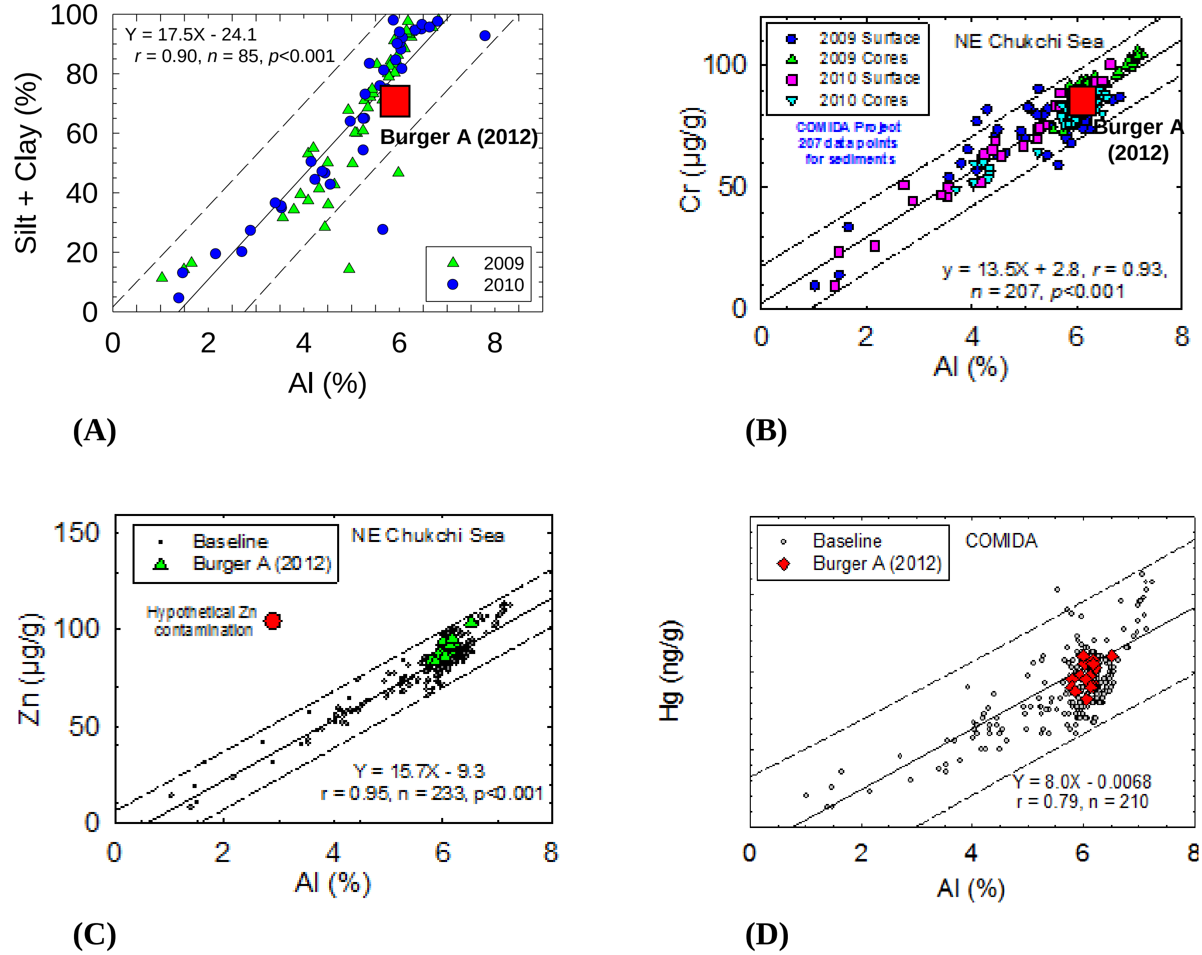


Figure 10: Concentrations of (A) silt + clay vs. Al, (B) Cr vs. Al, (C) Zn vs. Al, and (D) Hg vs. Al, for surface sediments from baseline stations throughout the northeastern Chukchi Sea. Equations and solid lines are from linear regression calculations for the 2009-2010 data from the COMIDA project (Dunton et al. 2012); dashed lines show 99% prediction intervals; *r* is the correlation coefficient; *n* is the number of samples; and *p* is the probability factor.

For the northeastern Chukchi Sea, a complete series of 17 plots of metal concentrations versus Al concentrations, such as those in Figures 9B, C and D, have been prepared (Trefry et al. 2012, and included on reference CDs submitted with this document) to define baseline concentrations for 17 of the metals listed in Table 3. In other words, a master baseline for the northeastern Chukchi Sea has been established for essentially the same metals listed by the Permit No.: AKG-28-8100 for analysis at the proposed drill sites. Naturally occurring metal concentrations in samples collected from a new location in the northeastern Chukchi Sea, such as the proposed Burger drill sites, should plot within the established prediction intervals on the relevant graph. Significant and positive deviations from the linear trend, such as shown by a hypothetical example for Zn contamination (Figure 10C), can then be used to identify metal contamination (or diagenetic remobilization) as described in more detail within Trefry et al. (2003).

The metal concentrations in surface sediments from the Burger A drill site are very uniform. The concentrations of 19 metals in 18 sediment samples collected from the Burger A drill site during

2012 had an average relative standard deviation (RSD) of ~7% (Table 3; also see sampling locations in Figure 1). This represents very low variability between samples for most metals associated with water-based fluids and drill-cuttings, and further supports that sediment characteristics within the Burger Prospect are uniform and adequately characterized. For Ag, Cd and MeHg, RSDs >10% were due in part to the very low natural concentrations of these metals. The high RSD for As was due to As enrichment in surface sediments at a few stations due to natural diagenetic processes (see Table 1 in Trefry et al. 2010).

The data in Table 3 can be considered to represent baseline metal concentrations for the Burger Prospect, and fall within the broad-scale baseline data set for the northeastern Chukchi Sea described above.

Table 3: Concentrations of metals (mean ± SD) in sediment samples from 2012 study of Burger A drill site.

Parameter (n = 18)	Ag (µg/g)	Al (%)	As (µg/g)	Ba (µg/g)	Be (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (%)	Total Hg (ng/L)
Mean	0.14	6.09	13.0	625	1.4	0.19	85	17.0	3.5	39
SD	0.02	0.17	3.3	14	0.1	0.02	3	1.3	0.2	3
RSD[1]	14	2.8	25	2.2	7.1	10	3.5	7.7	5.7	7.7

Parameter	MeHg (ng/g)	Mn (µg/g)	Ni (µg/g)	Pb (µg/g)	Sb (µg/g)	Se (µg/g)	Sn (µg/g)	Tl (µg/g)	V (µg/g)	Zn (µg/g)
Mean	0.14	6.09	13.0	625	1.4	0.19	85	17.0	3.5	39
SD	0.02	0.17	3.3	14	0.1	0.02	3	1.3	0.2	3
RSD[1]	14	2.8	25	2.2	7.1	10	3.5	7.7	5.7	7.7

[1]RSD = (SD/mean) x 100%.
Mn = manganese
V = vanadium

2.4. Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are the class of hydrocarbons that generally are of greatest interest from an environmental, ecological and toxicological perspective. Total PAH data for 29 sediment samples collected from the Burger Study Area in 2008 (i.e., CSESP) and 20 sediment samples collected from the Burger A drill site area in 2012 (i.e., Shell DMP) were analyzed in order to establish a baseline hydrocarbon site characterization for the Burger Prospect. Sample locations are shown in Figure 1 (green squares). The PAH data was compiled, analyzed and summarized with selected statistical methods and also plotted to compare concentrations within and among these data sets.

When comparing data between studies, it is important that target analytes and analytical methods are comparable and that any differences in methods are understood and can be accounted for. The 2008 Burger Study Area and 2012 Burger A drill site sediment samples were collected the same way, were analyzed by the same laboratory with the same methods, and therefore can be compared with confidence. The samples were collected to represent the top 2 cm of the surface sediment, the target analytes were the same, and the analytical methods used were the same. A total of 42 PAH parameters, including several alkylated PAH homologous series, were measured in the Total PAH analysis. The Total PAH analytical results for the two Burger datasets are summarized in Table 4. The mean concentrations for the Total PAH compounds are presented along with the SD and the minimal (Min) and maximal (Max) sample concentrations. These data also are presented graphically in Figures 10 and 11.

Table 4: Summary of concentrations of hydrocarbons (µg/kg dry weight [DW]) in the upper 2 cm of sediments at the Burger Study Area (2008) and the Burger A drill site (2012) in the Chukchi Sea**.**

	Burger Study Area (29 samples)				**Burger A drill site (20 samples)**			
Hydrocarbon parameter	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
Total PAH (Σ42)	300	93.1	121	482	304	25.0	264	365

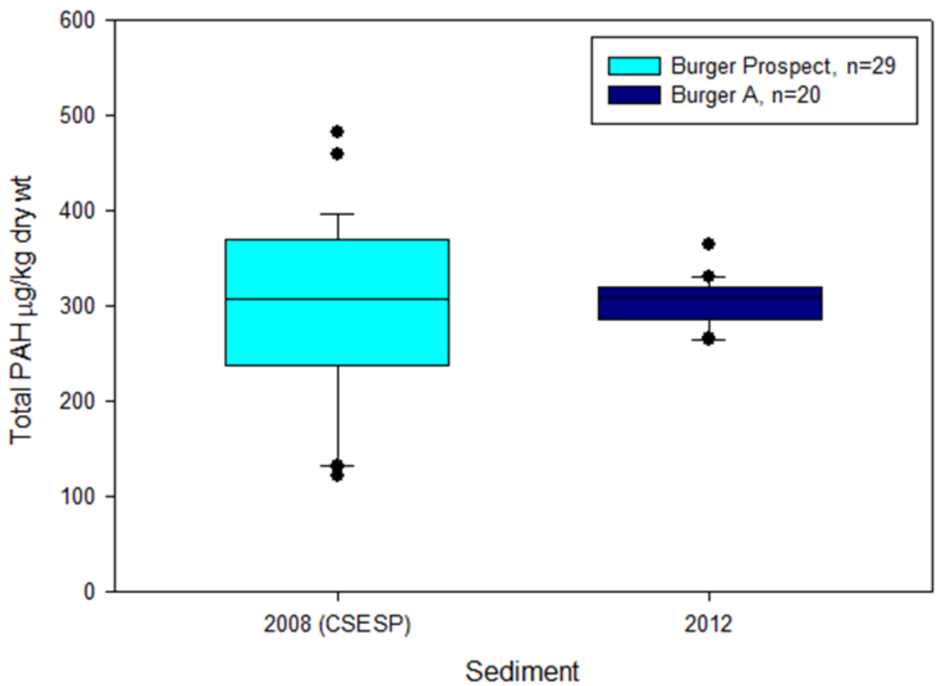


Figure 11: Summary of Total PAH concentrations (µg/kg DW) in sediment samples from the Burger Study Area (2008) and the Burger A drill site (2012) of the Chukchi Sea. Horizontal line in the box represents the median value. The vertical lines extend to the smallest and largest non-outlier values and the black dots represent actual data points that fall outside the first and third quartiles.

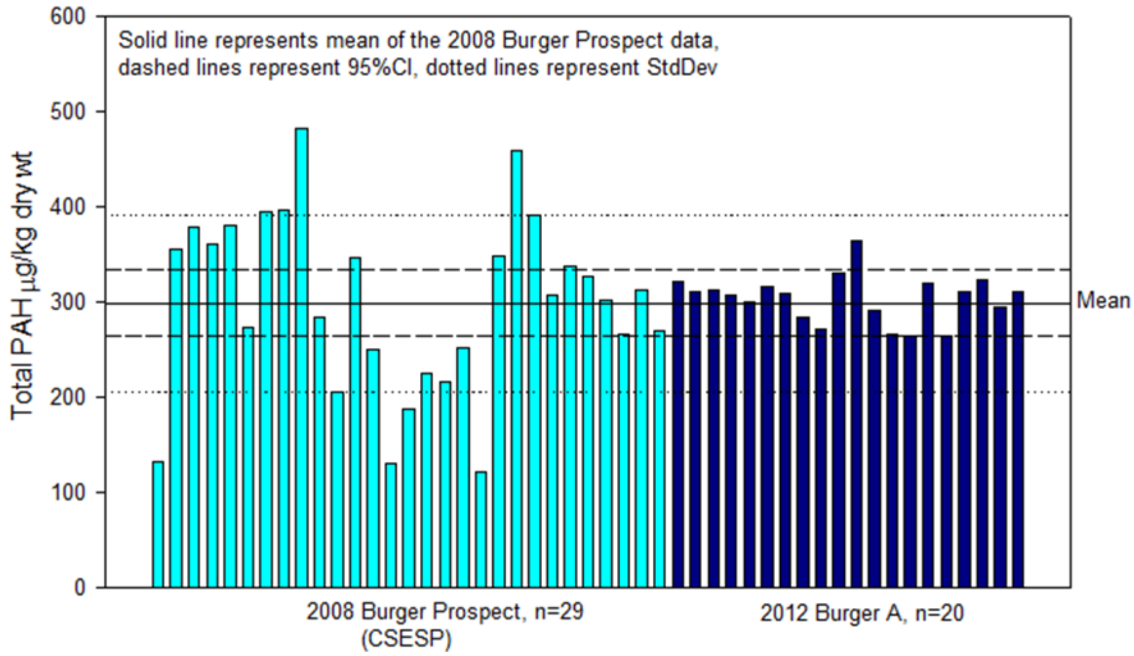


Figure 12: Total PAH concentrations (µg/kg DW) in sediment samples from the Burger Study Area (2008) and the Burger A drill site (2012) of the Chukchi Sea with the mean concentration, the 95% confidence intervals (dashed lines), and the SD (dotted lines) shown for the Burger Study Area samples.

Average sediment Total PAH concentration for 2008 Burger Study Area samples and Burger A drill site samples was 300 and 304 µg/kg DW, respectively. Variability within those two datasets was slightly greater for the Burger Study Area samples (Figure 11) than the Burger A drill site samples, with a SD of 93 µg/kg DW (Table 4) that translates to a %RSD of 30. In contrast, variability was very small for the Burger A drill site samples, which had a SD of 25 µg/kg DW (%RSD of 8%).

The data assessment also included normalizing the PAH concentrations to common data-normalizing parameters, to account for natural variability due to differences in sediment characteristics that may otherwise confound the data analysis. These sediment characteristics included using sediment TOC concentration, grain size (represented by the %fines [silt + clay]), and perylene (a non-petroleum, primarily biogenic, PAH that is abundant in some sediments). PAH concentrations in the Burger Study Area and the Burger A drill site generally covaried with all three parameters, increasing with increasing %TOC, %fines, and perylene (Figure 13). These relationships were not strong and did not indicate that these were major drivers of the PAH concentrations. The %TOC and %fines, however, may help to predict site-specific hydrocarbon concentrations. For example, the Burger Study Area TOC-normalized Total PAH concentrations were predictive of the Burger A drill site concentrations (Figure 13).

One-way analyses of variance (ANOVA) and Mann-Whitney tests were conducted on both data sets in order to compare the Burger Study Area and the Burger A drill site sample results to test for differences or similarities. As illustrated in Table 5, Total PAH concentrations in sediment samples were not significantly different between the Burger Study Area and the Burger A drill site (p = 0.879).

The data from the Burger Study Area are very similar to those from the Burger A drill site and appear to be highly predictive of baseline concentrations in the Burger A drill site (Figure 13). Mean Total PAH concentration is statistically equivalent for these two datasets (300 and 304 µg/kg DW), and the mean and confidence intervals for the Burger Study Area data generally predict the concentration range that would be expected at a specific location within the broader Study Area, such as at Burger A drill site (dashed lines in Figure 12), with few exceptions. As expected, the SD for the Burger Study Area data (dotted lines in Figure 12) covers a slightly wider range than does the confidence intervals and fully captures variation in the site-specific data. These predictions are based solely on sediment PAH concentrations and incorporate differences from varying sediment characteristics (e.g., TOC content, grain size). The prediction can be refined further by factoring in the small influence TOC content and grain size have on PAH concentrations in the Burger Study Area and Burger A drill site (Figure 13).

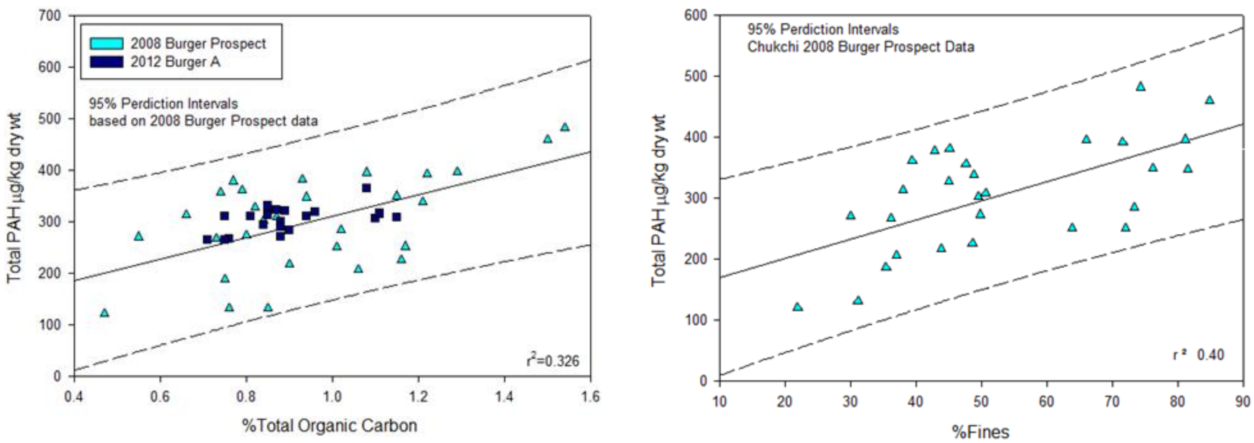


Figure 13: Total PAH concentration (µg/kg DW) vs. %TOC for the Burger Study Area (2008) and the Burger A drill site (2012) samples (left), and the Total PAH concentration (µg/kg DW) vs. % fines for the Burger Study Area (2008) samples (right).

Table 5: Mann-Whitney tests for difference in median concentration of PAH (µg/kg DW) in the upper 2-cm of sediments between the Burger Study Area (2008) and the Burger A drill site (2012).

	Burger Study Area (29 samples)	**Burger A drill site (20 samples)**		
Parameters	**Median**	**Median**	***U*-statistic**	***p*-value**
Total PAH	308	310	492	0.879

In conclusion, the recent and historical data sets have provided sufficient baseline physical site characteristics (currents, water column properties, and sediment concentrations) so that potential discharge related impacts can be evaluated at the proposed drill sites within the Burger Prospect when combined with data collected during Phases II, III, and IV of the EMP.

3. RECEIVING WATER CHEMISTRY

Permit No.: AKG-28-8100 Section II.A.13.f.3

Receiving Water Chemistry and Characteristics. Collect water chemistry data to characterize the receiving waters. This monitoring should include an assessment of pollutants that are expected to be present in discharge effluent and for which there are federal water quality criteria and/or state water quality standards. These parameters include dissolved metals, pH, turbidity, total suspended solids, total aqueous hydrocarbons, and total aromatic hydrocarbons. The metals monitoring must include, at a minimum, the metal contaminants of concern listed in Table A, below. The permittee may propose an alternative list based on site-specific data.

The purpose of this section is to summarize available receiving water chemistry analytical results and specifically addresses natural parameters (e.g., dissolved metals, pH, total suspended solids) and potential contaminant parameters (TAH and TAqH).

3.1. Metals

Concentrations of dissolved metals were determined for 6 samples from the Burger Study Area and 88 samples from the northeastern Chukchi Sea during 2010. The analytical results were compiled, analyzed and statistically summarized. As illustrated in Table 6, the concentrations of dissolved metals in northeastern Chukchi Sea water samples are generally consistent with Burger Study Area samples. Concentrations of some metals, including arsenic (As), barium (Ba), antimony (Sb), selenium (Se) and thallium (Tl), tend to track salinity values and have small RSD values of 3% to ~20% in both the Burger Study Area and throughout the northeastern Chukchi Sea region (Table 6 and As vs. salinity shown in Figure 14A).

Table 6: Concentrations of dissolved metals (mean ± SD) for water samples from 2010 for the Burger Study Area and northeastern Chukchi Sea. For reference, TSS (mean ± SD) are also reported. Note that the Burger Study Area dataset is a subset of the Northeastern Chukchi Sea dataset.

Parameter	As	Ba	Cd	Cr	Cu	Total Hg	Ni	Pb	Sb	Se	Tl	Zn	TSS
Burger Study Area (2010; *n* = 6)													
Mean	1.16	7.7	0.046	0.13	0.24	0.0005	0.32	0.004	0.13	0.034	0.009	0.33	0.59
SD	0.04	1.2	0.024	0.07	0.04	0.0003	0.08	0.002	0.01	0.002	0.001	0.06	0.52
RSD[1]	3	16	52	54	17	60	25	50	8	6	11	18	-
Northeastern Chukchi Sea (2010; *n* = 88)													
Mean	1.15	8.2	0.046	0.10	0.27	0.0005	0.32	0.006	0.12	0.034	0.010	0.45	0.80
SD	0.12	2.0	0.021	0.02	0.10	0.0003	0.08	0.002	0.01	0.006	0.002	0.26	0.88
RSD[1]	10	24	46	20	37	60	25	33	8	18	20	58	-

metals measurements = µg/L
TSS = mg/L
[1]RSD = (SD/mean) x 100%

Inorganic micronutrient metals, including copper (Cu), nickel (Ni) and zinc (Zn), are present in low concentrations in nutrient-depleted surface waters and are enriched due to remineralization in bottom waters (Figure 14B, which depicts an example of the nutrient phosphate enriched in bottom waters); therefore, concentrations of these metals correlate strongly with concentrations of nutrients such as dissolved phosphate (Figure 14C). Average concentrations of lead (Pb) and total mercury (Hg) are very low, at <5 and 0.5 parts per trillion (ng/L), respectively.

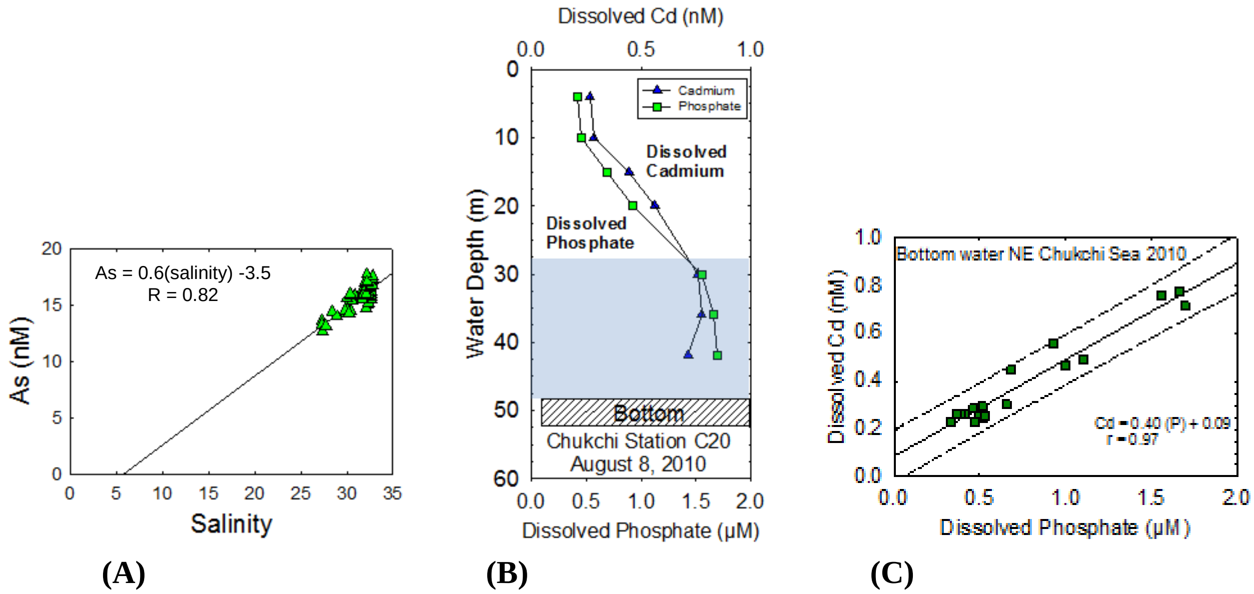


Figure 14: (A) Dissolved As vs. salinity, (B) vertical profiles for dissolved phosphate and Cd, a nutrient-type metal, and (C) concentrations of dissolved Cd vs. phosphate for bottom water in the northeastern Chukchi Sea (from Dunton et al. 2012).

The existing baseline data for dissolved metals include 12 of the metals listed as required in the NPDES permit (Table A, p. 21). Seven metals (Al, Be, Fe, methyl Hg, Ag, Sn, and Ti) were not analyzed as part of the CSESP or Shell DMP studies. To obtain this information, receiving water samples will therefore be collected during or immediately before the Phase II (during drilling) component at reference stations in areas located approximately 1,000 m and beyond from the drilling discharge location. These water samples will also serve as reference samples for evaluation of receiving-water chemistry. The comparison between the collection of water samples, both within and outside of the discharge plume(s), will serve as a more robust means of determining differences between elevated metals concentrations in the plume and the typical "background" metals concentrations in Chukchi Sea receiving waters.

3.2. Receiving water pH, Turbidity, and Total Suspended Solids of Northeast Chukchi Sea

Data on pH, turbidity and total suspended solids are well characterized in receiving waters in the Burger Study Area. The pH data for the Burger Study Area were estimated from data collected during the CSESP program in 2010 and 2011 (Mathis 2011). The pH values were calculated from total alkalinity measurements and, for the months of August and September 2010, averaged

8.16 ± 0.08 (SD) at a water depth of 1 m, 8.18 ± 0.09 (SD) at 5 m, and 8.15 ± 0.07 (SD) at 10 m (Mathis, 2011). Turbidity and total suspended solids baseline data in the Burger Study Area and northeastern Chukchi Sea were addressed in Physical Characteristics (Section 2.2.4).

3.3. Total Aromatic Hydrocarbons and Total Aqueous Hydrocarbons

Due to permit requirements receiving water samples will be collected during or immediately before the Phase II (during drilling) component at reference stations in areas located approximately 1,000 m and beyond from the drilling discharge location(s). These water samples will also serve as reference samples for evaluation of receiving water chemistry and characteristics affected by the discharge plume(s). The comparison between the collection of water samples, both within and outside of the discharge plume(s), will serve as a robust means of determining differences between elevated hydrocarbon concentrations in the plume and the typical "background" hydrocarbon concentrations in Chukchi Sea receiving waters.

However, concentrations of total aromatic and total aqueous hydrocarbons in water typically are very low and do not provide a representative baseline evaluation over a temporal scale. Sediment and tissue concentrations (as well as source samples, such as water-based drilling fluids and drill-cuttings) are more reliable for monitoring and assessing impacts of hydrocarbons from exploratory drilling operations. Baseline hydrocarbon concentrations from recently collected seafloor sediments and biota tissue are provided in this appendix. In the case of the seven dissolved metals and hydrocarbon concentrations in water that are not available for baseline information, the collection of these data has been addressed and will be conducted immediately prior to or during Phase II monitoring at contemporaneous reference stations. The absence of these water concentrations does not weaken the conclusion that the already existing baseline information in the northeastern Chukchi Sea are sufficient to serve as Phase I baseline data.

4. BENTHIC COMMUNITY STRUCTURE

Permit No.: AKG-28-8100 Section II.A.13.f.4

Benthic Community Structure. Describe the composition of the drilling site's benthic community (infaunal and epifaunal invertebrates, bivalves, and crustaceans).

The purpose of this section is to provide a synthesis of the available benthic ecology data and a summary of recent efforts to establish baseline bioaccumulation data for the Burger Prospect area.

4.1. Benthic Ecology Data

The ecology of benthic communities in the northeastern Chukchi Sea has been a focus of research since the 1970s. Initial research in the area by U.S. scientists was conducted by Stoker (1981), who demonstrated broad-scale trends across the Bering and Chukchi Seas. Feder et al. (1994) sampled benthic communities in the northeastern Chukchi Sea in 1986, providing details on the environmental characteristics associated with benthic community structure. Later, in the early 2000s, research programs such as Russian-American Long-Term Census of the Arctic (RUSALCA) and the Shelf Basin Interactions project evaluated benthic communities from the western and northeastern Chukchi Sea and investigated ecological processes at the shelf margin (Grebmeier et al. 2006, 2009; Bluhm et al. 2009).

Localized sampling of infaunal and epifaunal communities, with the specific goal of acquiring baseline benthic community structure data, began in 2008 with the initiation of the CSESP program. In 2010 and 2011, larger-scale investigations were initiated by both the CSESP and COMIDA CAB programs (Dunton et al. 2012; Blanchard et al. 2013a, 2013b).

Overall, the CSESP sampled 26 stations for benthic infauna in the Burger Study Area annually from 2008 to 2012, and 9 of those 26 stations were sampled in both 2011 and 2012. Two stations were sampled for infauna in the Burger Study Area during the COMIDA CAB program (Dunton et al. 2012). In addition, 18 baseline samples were also collected in 2012 at the Burger A drill site location as part of the Shell DMP. Infaunal samples were identified to species level. Trawling for epifauna occurred at 13 stations in the Burger Study Area from 2009 to 2010 (as part of CSESP) with two stations sampled for epifauna (as part of COMIDA CAB). Epifaunal data were not identified to species level (a more qualitative analysis), and thus are presented as common names. These research programs have provided an important data set for understanding the benthic community characteristics of the Burger Prospect and the six proposed drill sites, as summarized in detail below.

The infaunal community in the Burger Study Area is dominated numerically by polychaetes and bivalves (Table 7). The maldanid polychaete worm *Maldane sarsi* is a numerically dominant organism throughout the offshore environment of the northeastern Chukchi Sea by density and biomass with extremely high densities at some sites in Burger Study Area (Feder et al. 1994; Blanchard et al. 2011, 2013a, 2013c). The polychaete *Scoletoma* spp. and crustaceans, including ostracods and amphipods such as *Photis* spp., also occur in moderate densities. The bivalve *Ennucula tenuis* is a dominant organism by density and biomass, with larger bivalves such as *Astarte borealis* and *Macoma calcarea* and the peanut worm *Golfingia margaritacea* contribute substantially to the overall biomass as well.

Table 7: Numerically dominant organisms (top 5) by density (individuals m^{-2}) and biomass (grams m^{-2}) for the Burger Study Area. Values are averaged from the 2008-2011 studies.

Infauna			
Taxon[1]	**Density (individuals m^{-2})**	**Taxon**	**Biomass (grams m^{-2})**
Maldane sarsi	1,093	*Astarte borealis*	45.7
Ostracoda	282	*Macoma calcarea*	43.7
Ennucula tenuis	203	*Golfingia Margaritacea*	40.4
Scoletoma spp.	140	*Maldane sarsi*	40.1
Photis sp.	129	*Ennucula tenuis*	28.9
Epifauna			
Common name[1]	**Density (individuals m^{-2})**	**Common name**	**Biomass (grams m^{-2})**
Brittle stars	86.1	Brittle stars	55.2
Snails	3.5	Snails	5.6
Sea cucumbers	3.1	Sea cucumbers	4.5
Shrimps	1.9	Crabs	3.3
Amphipods	0.5	Basket stars	2.1

[1] Infauna are listed by taxon whereas epifauna are listed by common name because of differing methodologies for collection. Infauna were collected quantitatively using grab sampling, while epifauna were semi-quantitative using trawls and/or underwater camera.

The epifaunal community is dominated numerically by the brittle star *Ophiura sarsi* in the Burger Study Area and throughout many parts of the northeastern Chukchi Sea (Table 7; Bluhm et al. 2009; Blanchard et al. 2011, 2013a, 2013b). Sea cucumbers and snails are also dominant.

Benthic infaunal communities are naturally patchy in terms of abundance and distribution. In order to evaluate this community-level variation, infauna were ranked by density and biomass. In addition, comparisons of dominant organisms via station rankings can provide insights into what constitutes acceptable ranges of community variation in density and biomass within the Burger Study Area. Community-level variations among stations were evaluated by ranking infauna from the station with the lowest density versus the highest density from 2008 to 2011 (see Table 8). The rankings provided insights into communities under different environmental regimes in Burger Study Area stations, and a background for comparing other Burger drill sites. The numerically-dominant species in the stations with minimal (BF025 in 2010) and maximal (BF013 in 2011) densities reflect the overall dominant organisms in the Burger Study Area and within the entire CSESP Study Areas (Blanchard et al. 2013b). The dominant species in both stations are organisms that are found throughout the three study qreas and that are common in soft sediments (i.e., none of the species or patterns of composition deviate from the expected patterns for the area).

Table 8: Numerically dominant organisms (top 5) by density (individuals/m^2) and biomass (g/m^2) for the station with the lowest and highest density values for the Burger Study Area from the 2008-2011 CSESP.

Year	Station	Taxon	Abundance	Taxon	Biomass
2010	BF025	*Macoma calcarea*	193	*Macoma calcarea*	215.44
		Cirratulidae	77	*Macoma moesta*	13.31
		Dipolydora sp.	57	*Ennucula tenuis*	12.80
		Ennucula tenuis	50	*Periploma aleuticum*	12.74
		Pholoe minuta	43	*Cyclocardia crebricostata*	6.67
		Nephtys punctate	13	*Priapulus caudatus*	0.93
2011	BF013	*Maldane sarsi*	9,443	*Neptunea heros*	107.24
		Ostracoda	1,083	*Golfingia margaritacea*	82.73
		Ennucula tenuis	550	*Ennucula tenuis*	55.40
		Photis sp.	437	*Cyclocardia crebricostata*	10.36
		Barantolla americana	230	*Musculus discors*	5.24

The, benthic communities in the Burger Study Area, based on this 2008-2011 data, are similar in composition to those found in prior years and within the Chukchi Sea as a whole (Feder et al. 1994; Grebmeier et al. 2006). The dominance of densities by *Ennucula tenuis* and *Maldane sarsi* and of biomass by large bivalves in 1986 (Feder et al. 1994) and 2008-2010 (Blanchard et al., 2011, 2013a, 2013b) demonstrates that, at least very broadly, communities have temporally persistent biological characteristics when compared with organisms listed in Feder et al. (1994).

The numerically dominant species and the benthic assemblages in general are present because of the influence of species advected into the Chukchi Sea from the north Pacific through the Bering Sea (Feder et al. 1994; Grebmeier et al. 2006; Bluhm et al. 2009; Dunton et al. 2012; Blanchard et al. 2013a, 2013b). The northward-flowing water advects benthic larvae and organisms into the Arctic, resulting in a high similarity of communities from the Gulf of Alaska to the northeastern Chukchi Sea (Blanchard et al. 2013a). Overall, the benthic community in the Burger Study Area observed throughout the multi-year sampling period (2008-2011) is a common assemblage found in soft-bottom and muddy sediments throughout Alaska.

The importance of advected water on benthic communities is now understood, with distinct benthic assemblages being strongly influenced by sediment characteristics and the nutrient characteristics of overlying water masses (Feder et al. 1994; Grebmeier et al. 2006). Associations between environmental characteristics and benthic communities are due to the covariance of sediment characteristics and faunal communities with water circulation. Of particular importance for the Burger Prospect Area is the understanding that increased benthic productivity is more apparent in areas with altered water circulation (e.g., points, shoals and canyons) (Feder et al. 1994, 2007; Grebmeier et al. 2006).

5. EXISTING DATA ARE ADEQUATE TO SERVE AS BASELINE SITE CHARACTERIZATION DATA FOR POST-DRILLING MONITORING AT PROSPECTS

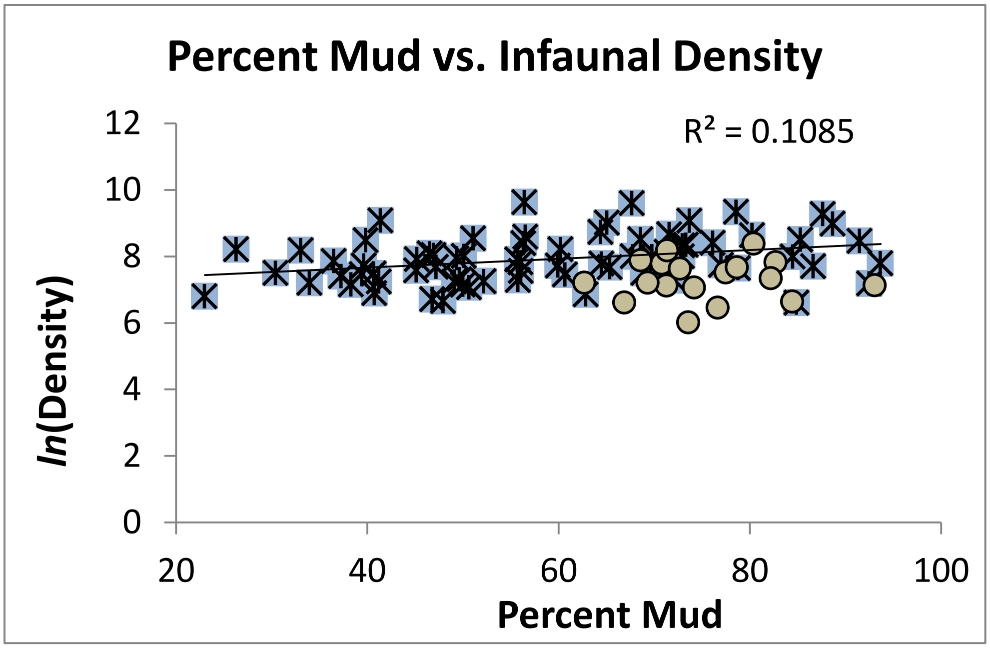
The multi-year CSESP data from the Burger Study Area were compared to the Burger A data from 2012 to determine if the data from the CSESP program are adequate to serve as a baseline for post-drilling monitoring at the Burger Prospect. Data were compared using faunal rankings and regression analysis to determine whether results from the Burger A drill site location fall within the trends observed in the data sets from the Burger Study Area.

Data from three replicate samples collected at each station indicate that the greatest difference between the Burger A drill site overall and the Burger Study Area stations is that the numbers of *Maldane sarsi* in the Burger A drill site are low (Table 9). The remaining numerically dominant organisms at the Burger A drill site, however, also were found throughout the Burger Study Area. Densities of *M. sarsi* in the Burger Study Area ranged from an average of 3 to 9,500 individuals m^{-2} at some stations, whereas preliminary densities from the 2012 sampling at Burger A ranged from 10 to 70 individuals m^{-2}. Overall, densities appear to be toward the low end of the range. The location-specific community, however, fits well within the community-level variability observed within the Burger Study Area stations (Tables 7 and 8). The similarity of the stations is indicated by the consistent presence of key dominant species throughout the drilling location including *Barantolla americana, Ennucula tenuis, Golfingia margaritacea, Macoma calcarea* and *Maldane sarsi,* all of which are found in Burger A drill site stations.

Table 9: Numerically dominant organisms (top 5) by density (individuals m^{-2}) and biomass (g m^{-2}) for the Burger A drill site. Values are averaged from 18 stations sampled at Burger A drill site in 2012. The density and biomass of *Maldane sarsi* also are presented, although they are not in the top 5 in either category.

Taxon	Density	Taxon	Biomass
Ostracoda	276	*Golfingia margaritacea*	87.6
Ennucula tenuis	202	*Macoma calcarea*	62.7
Barantolla americana	99	*Ennucula tenuis*	22.6
Ektondiastylis robusta	79	*Ophiura sarsi*	11.7
Terebellides stroemi	66	*Paradiopatra parva*	5.5
Maldane sarsi	31	*Maldane sarsi*	2.6

Community characteristics of the Burger A drill site were also evaluated with regression analysis. Total infaunal density and biomass for the Burger Study Area stations from the 2008-2011 CSESP and the Burger A drill site from the 2012 DMP were regressed against percentage of mud in the sediments (see Figure 15). The biological data were log normally-transformed to address statistical assumptions. The relationships between the percentage of mud in the sediments and the biological variables are weak, with R^2 accounting for 10% of the total variability in infaunal density and only 3% of total variability for biomass. (Low R^2 values are not uncommon when considering a single variable in benthic studies and can be improved dramatically with the addition of other covariates).



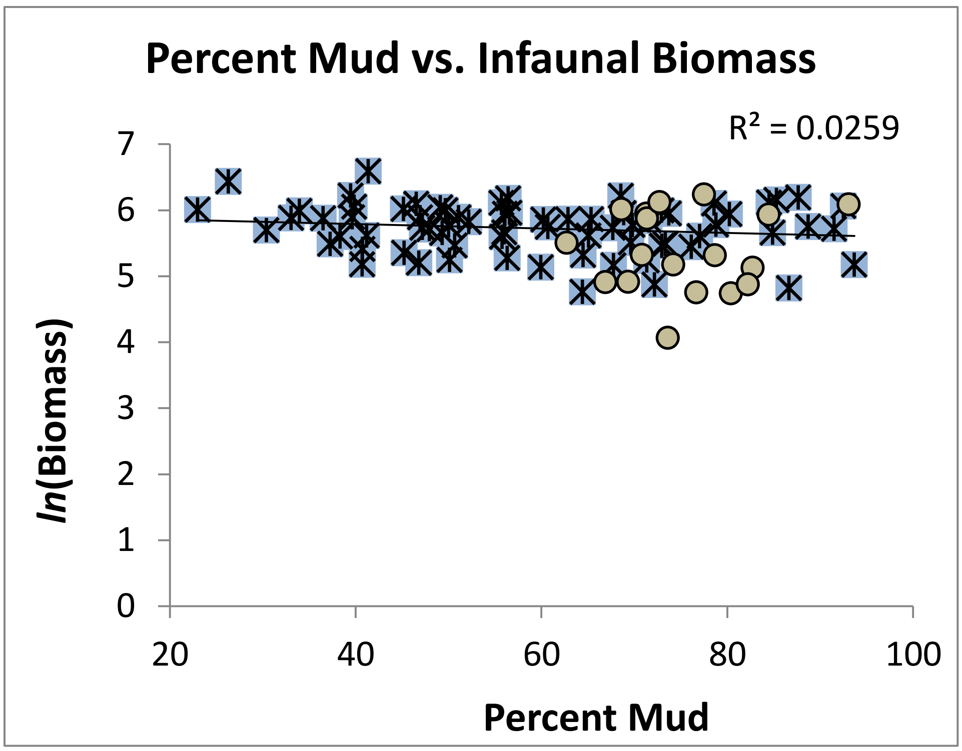


Figure 15: Percent mud regressed against *ln*-transformed infaunal density (top) and biomass data (bottom) from the 2011 CSESP study of the Burger Study Area and Burger A drill site samples from 2012 (DMP).

These comparisons demonstrate that the baseline samples collected at Burger A drill site in 2012 are consistent with the ranges measured for the Burger Study Area stations. Although more muddy than most stations, the Burger A drill site stations fall well within the boundaries of the regression, based on the other Burger Study Area stations.

In conclusion, although the preliminary community structure does vary somewhat from that expected for the Burger Study Area due to low numbers of *M. sarsi* (Tables 7 and 8 vs. Table 9), the benthic community structure falls within the general trends identified at the Burger Study Area. The comparison of the data clearly demonstrate that the benthic community structure at the Burger A drill site is representative of the community structure gradients in Burger Study Area and can be considered sufficient baseline site characterization data for the proposed drill site locations within the Burger Prospect.

5.1. Bioaccumulation Data

Bioaccumulation monitoring is a required component of Phase I baseline site characterization in order to discharge water-based drilling fluids and drill-cuttings (D001).

Bioaccumulation is the uptake of chemicals over time in an organism. Coastal monitoring programs have existed in the U.S. for many decades (e.g., the "Mussel Watch Program," U.S. National Status and Trends Program) and primarily have used clams (or bivalves) to measure the bioaccumulation of various persistent organic pollutants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides such as dichlorodiphenyltrichloroethane (DDT) (Gunther et al 1999). Bioaccumulation of metals historically has also been monitored by using immobile, sentinel clams (or bivalves). For example, mussels and oysters have been used for such purposes in the U.S. National Status and Trends Program from 1986 to present (Kimbrough et al. 2008).

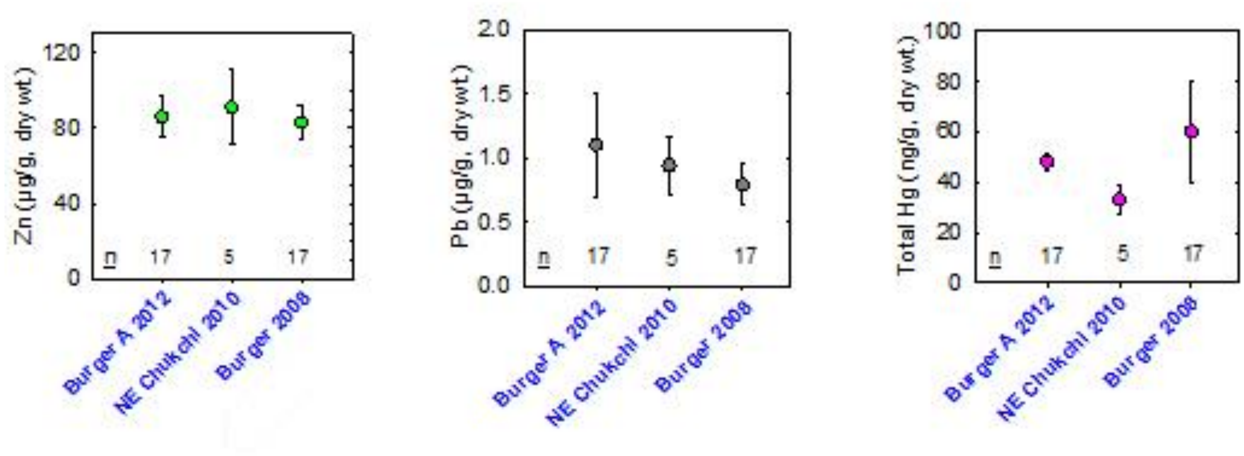
Clams are often used because they are an important indicator animal for monitoring contaminants in the environment, because they are sessile and are useful for conservatively assessing bioaccumulation potential. They effectively accumulate bioavailable contaminants such as PAHs and do not readily metabolize or excrete such compounds like many other animals do. By measuring the chemical body burden in the tissues of organisms that do not readily metabolize the compounds of interest, an estimate of the amount of compound that is bioavailable (i.e., actually taken up by the organism) in the water or sediment can be determined. By examining organisms at the lower level of the food chain (e.g., clams or bivalves), a greater understanding can be gained of the magnitude of chemical concentration through the food web. The simplest way to estimate bioaccumulation is to determine the concentrations of chemicals of interest in the organisms of interest and compare these to concentrations in the sediment.

Clams (*Astarte* spp.) have been used for monitoring bioaccumulation in the Chukchi and Beaufort seas (e.g., Neff et al. 2009, 2010; Dunton et al. 2012). It is important to note that significant issues exist for collection of clams in the Chukchi Sea due to natural patchiness in abundance, challenges with obtaining sufficient tissue mass for laboratory chemical analysis, difficulty with collecting tissue samples of identical species, and gut contributions to body-burden measurements. Furthermore, chemical concentrations in biota are typically more variable than those in sediments. As such, these data are not as effective at demonstrating moderate changes in chemical concentrations due to anthropogenic impacts.

Provided below is a summary of the available baseline data that describes bioaccumulation of chemicals in benthic organisms for the Burger Prospect.

5.1.1. Metals

Metal concentrations in clams collected during 2012 from the Burger A drill site were highly variable, with an average RSD of 39% (Table 10). Zinc, which is an essential element for clams, is regulated biochemically by Zn-bearing enzymes; consequently, variations in clam Zn concentrations (RSD = 12%) were smaller than observed for some non-essential metals such as Cd, Pb and Sn (Table 10 and Figure 16 for Zn, Pb and Hg).



(A) **(B)** **(C)**

Figure 16: Means (marker) ± SDs (lines) for concentrations of (A) Zn, (B) Pb, and (C) total Hg for clams (*Astarte* spp.) from Burger A drill site and other areas in the northeast Chukchi Sea (*n* = number of samples).

Table 10: Concentrations of metals (mean ± SD) for clam (*Astarte* spp., wet weight) samples from 2012 for Burger A drill site and other northeast Chukchi Sea locations.

Parameter	Ag (µg/g)	As (µg/g)	Ba (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (µg/g)	Total Hg (ng/g)
Burger A drill site (2012) (*n* = 18)								
Mean	0.26	13.1	21.6	13.5	1.3	15.3	2200	48
SD	0.11	4.3	4.5	13.1	0.4	2.2	746	3
RSD[1]	42	33	21	98	31	14	34	6
Burger Study Area and NE Chukchi Sea (2008, 2010, *n* = 20)								
Mean	0.22	11.8	14.2	34	1.3	9.6	1400	49
SD	0.16	1.4	9.6	12	0.3	2.5	770	19
RSD[1]	72	12	68	36	22	26	55	40

Parameter	MeHg (ng/g)	Ni (µg/g)	Pb (µg/g)	Se (µg/g)	Sn (µg/g)	V (µg/g)	Zn (µg/g)
Burger A drill site (2012, *n* = 18)							
Mean	7	5.6	1.1	4.2	0.14	5.7	86
SD	2	3.3	0.4	1.3	0.11	2.6	10
RSD[1]	33	58	39	30	83	46	12
Burger Study Area and NE Chukchi Sea (2008, 2010, *n* = 20)							
Mean	10	-	0.7	8.4	-	3.4	83
SD	2	-	0.1	1.5	-	2.2	11
RSD[1]	19	-	12	18	-	65	14

[1]RSD = (SD/mean) x 100%.

Metal data for clams from Burger A drill site (Table 10) provide a suitable baseline for identifying future assessment of metal contamination in biota. Overall metal concentrations in clams from the Burger A drill site are consistent with results for other locations in the Burger Study Area and throughout the northeast Chukchi Sea. The existing data from Burger A drill site and throughout the northeast Chukchi Sea, therefore, provide a suitable and valuable baseline for metals in clams from other locations in the northeast Chukchi Sea, including other Burger drill sites. As has been noted for the U.S. National Status and Trends Program (http://ccma.nos.noaa.gov/stressors/pollution/nsandt/), observed natural variations in metal concentrations in bivalves limit the sensitivity of identifying increased values due to contamination; however, marked metal contamination would still be discernible in these *Astarte* clams from the northeast Chukchi Sea.

5.1.2. Hydrocarbons

Two data sets on PAH chemistry in biological tissues from the Chukchi Sea were used to determine if sufficient baseline information exists for site-specific locations in the Burger Study Area. The samples were collected from the same two general areas as the samples used for the sediment Total PAH analyses discussed in Section 2 (i.e, samples from the Burger Study Area collected in 2008 and samples collected at the Burger A drill site in 2012). The data analysis presented focus on PAH concentrations in clams. PAHs were used to represent potential hydrocarbon contaminants because they are the class of analytes that are of greatest interest from a bioaccumulation and toxicological perspective.

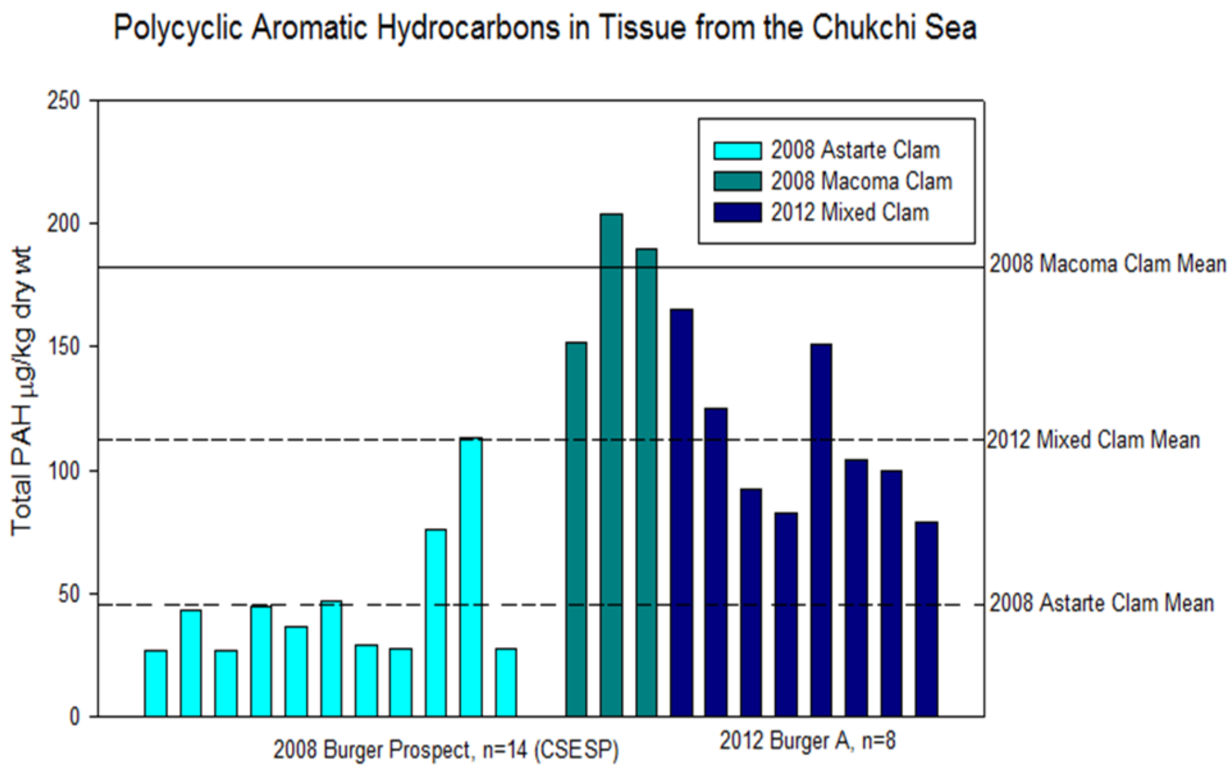
The Burger Study Area data set consisted of 11 *Astarte* spp. clam samples and three *Macoma* spp. clam samples collected in 2008. The Burger A drill site samples collected in 2012 consisted of 8 samples of a mixture of clam species. The PAH analytical results for the two Chukchi Sea datasets are summarized statistically in Tables 11 and 12: Table 11 shows the data on a DW basis; Table 12 shows the data on a lipid-normalized basis. Mean Total PAH concentrations are presented along with the SD, 95% confidence interval (CI), and the minimum and maximum sample concentrations. These data also are presented graphically in Figure 17.

Table 11: Total PAH concentration (µg/kg DW) in clams collected in the Burger Study Area in 2008 and at the Burger A drill site in 2012.

Study Area	Sample Type	*n*	Mean	SD	C.I. of Mean	Min	Max
2008 Burger Study Area	*Astarte* clam	11	45.3	26.8	18.0	26.7	113
	Macoma clam	3	182	26.9	66.8	152	204
2012 Burger A drill site	Mixed clam	8	113	31.9	26.6	79.1	165

Table 12: Total PAH concentration (µg/g lipid) in clams collected in the Burger Study Area in 2008 and at the Burger A drill site in 2012.

Study area	Sample Type	*n*	Mean	SD	C.I. of Mean	Min	Max
2008 Burger Study Area	*Astarte* clam	11	3.8	2.9	2.0	1.6	12.0
	Macoma clam	3	4.8	1.2	3.1	3.4	5.8
2012 Burger A drill site	Mixed clam	8	4.3	0.6	0.5	3.6	5.0



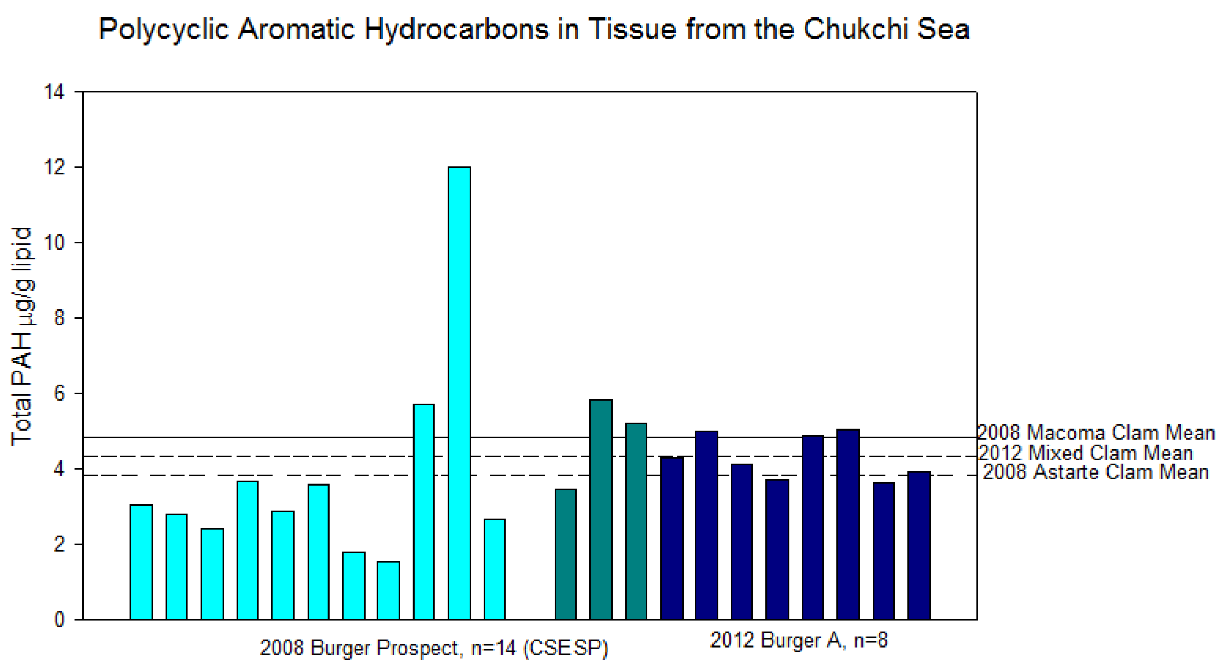


Figure 17: Total PAH concentrations in Chukchi clam samples from the Burger Study Area and Burger A drill site. Concentrations are in µg/kg DW (top) and µg/g lipid (bottom).

Average clam-tissue Total PAH concentrations for the 2008 Burger Study Area CSESP samples were 45.3 and 182 µg/kg DW for the *Astarte* and *Macoma* clams, respectively. The average Total PAH concentration was 113 µg/kg DW for the mixed-clam samples collected from Burger A drill site in 2012. There was clearly a large difference in mean PAH concentration between the two species; but, the variability within a species and the difference between the species was quite small once the data were lipid-normalized (Table 13 and Figure 17 [bottom]). The lipid content of the *Macoma* clam samples (which had the highest PAH concentrations on a DW basis) averaged 3.85%, and the average lipid content for the *Astarte* clams was 1.20%. As expected, lipid content drives the accumulation of PAH in these clam samples. The Total PAH concentration strongly co-varied with the amount of lipid in the sample (Figure 18), as can be expected for bioaccumulation of most hydrophobic organic compounds.

Table 13: Total PAH concentration (µg/g lipid) in clams collected in the Burger Study Area in 2008 and at the Burger A drill site in 2012**.**

Study	Sample Type	*n*	Mean	SD	C.I. of Mean	Min	Max
2008 Burger Study Area	Mixed clam	14	4.0	2.7	1.5	1.6	12.0
2012 Burger A drill site	Mixed clam	8	4.3	0.6	0.5	3.6	5.0

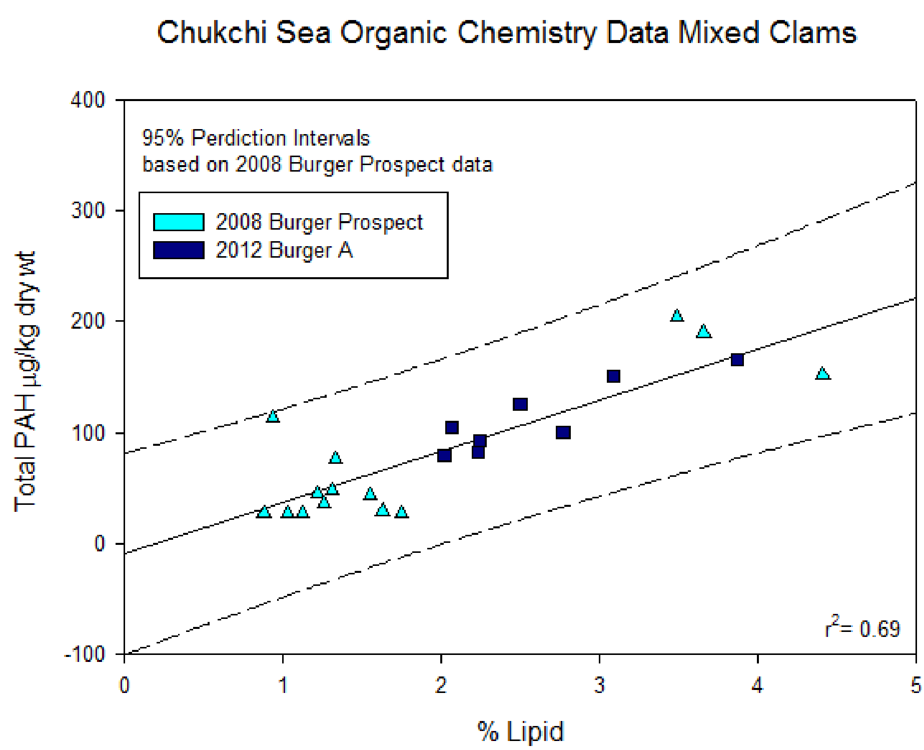


Figure 18: Total PAH concentration (µg/kg DW) vs. %Lipid for the Burger Study Area (2008) and the Burger A drill site (2012) and clam tissue samples.

Normalizing the data to the lipid content for the most part removes the influence that the specific clam species had on the data, and the *Astarte* and *Macoma* clam data can be combined for subsequent data analysis (Table 14 and Figure 19). Combining the data also makes it possible to compare the 2008 and 2012 data with greater confidence because the 2012 samples were a mixture of species (e.g., *Astarte*, *Macoma*, and possibly other). ANOVA and Mann-Whitney tests were also performed on both data sets, comparing them with each other to assess whether they differed (Table 14). The Total PAH (lipid-normalized) concentrations were not significantly different for samples collected in the Burger Study Area and in the Burger A drill site (p= 0.125).

Table 14: Mann-Whitney tests of data for clam tissue collected in the Burger Study Area in 2008 and at the Burger A drill site in 2012. Data for the 2008 *Astarte* and *Macoma* clams are combined (the 2012 clam samples consisted of mixed clam species).

	Burger Study Area 2008, *n*=14	**Burger A drill site 2012, *n*=8**		
Parameter and Concentration Basis	**Median**	**Median**	***U*-statistic**	***p*-value**
Total PAH (µg/kg DW)	44.0	102		
Total PAH (µg/g lipid)	3.20	4.20	115	0.125

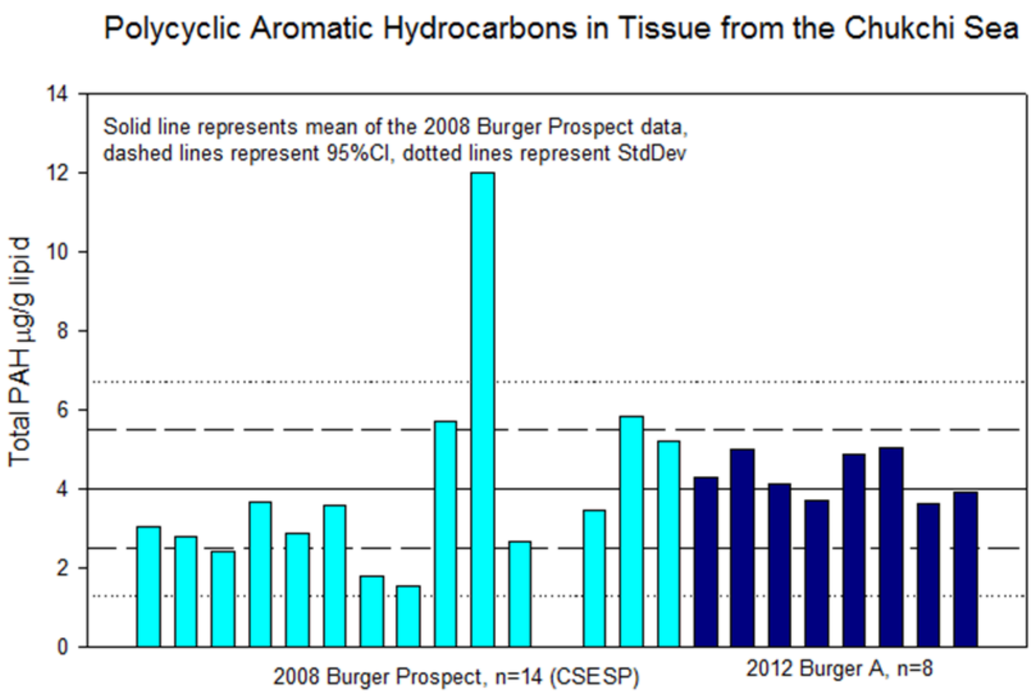


Figure 19: The Total PAH concentrations in Chukchi clam samples from the Burger Study Area and Burger A drill site. Concentrations are in µg/g lipid with the mean concentration, the 95% confidence intervals (dashed lines), and the SD (dotted lines) for the Burger Study Area data.

The data in Figure 18 suggest that most of the samples from 2012 are a mixture of *Astarte* and *Macoma* clams and possibly other species. The light blue triangles for the 2008 samples (%Lipid ~1-2%) are the *Astarte* clams, while the light blue triangles (%Lipid ~4%) are the *Macoma* clams. The dark blue squares represent the mixed clam samples collected in 2012, and those fall in between, suggesting that they may be a combination of mostly *Astarte* and *Macoma* because those are the most abundant clams in this area. The exception is the dark blue square towards the right (near 4%Lipid), which aligns with the 2008 *Macoma* samples, suggesting that 2012 sample may have been primarily composed of *Macoma* clams.

The lipid-normalized data from across the Burger Study Area (the 2008 CSESP data) are very similar to the 2012 Burger A drill site data and are highly predictive of site-specific Total PAH concentrations in clams collected anywhere within the Burger Study Area (Figure 19). The mean Total PAH concentration is statistically equivalent for these two Study Areas. The mean and confidence interval for the Burger Study Area data predict the probability that the PAH sediment concentrations fall within this range at a specific site, such as Burger A drill site (dashed lines in Figure 18). The 95% prediction interval for Total PAH concentration vs. %Lipid relationship is also highly predictive of the PAH concentration.

In conclusion, the baseline bioacccumulation data presented here are considered sufficient site-specific information to meet the EMP Phase I baseline data requirements for the six currently planned drill site locations within the Burger Prospect.

CONCLUSION

The goal of this document has been to present and demonstrate that sufficient Phase I site characterization data exist in the vicinity of the proposed drill sites per the Permit No.: AKG-28-8100 Section 2.A.13.f. This information is sufficiently representative of existing conditions at the Burger Prospect so that Shell and the EPA will be able to evaluate and assess potential impacts from authorized discharges. As presented in Sections 1 through 4, multiple comparisons of physical and biological data from the broader Burger Study Area to the Burger A drill site indicates that it is reasonable and sufficient to utilize the available prospect-level data as Phase I site characterization data at the six proposed drill site locations. In the case of the seven dissolved metals and hydrocarbon concentrations in water that are not available for baseline information, the collection of these data has been addressed and will be conducted during Phase II monitoring at contemporaneous reference stations. The absence of these water concentrations does not weaken the conclusion that the already existing baseline information in the northeastern Chukchi Sea are sufficient to serve as Phase I baseline data.

By studying specific areas such as the CSESP Burger Study Area, and then evaluating these findings with the results from other larger-scale investigations such as COMIDA CAB, several insights into the northeastern Chukchi Sea marine ecosystem processes have been developed. It is now generally accepted, for example, that the presence of distinct benthic community structures in the northeastern Chukchi Sea is clearly based on several interrelated oceanographic factors, including seafloor topography (water depth), large- and small-scale ocean currents, sediment characteristics, water column properties (receiving water chemistry), and food availability (Stoker 1981, Feder et al. 1994, Grebmeier et al. 2006, Bluhm et al. 2009, Dunton et al. 2012, Blanchard et al 2011, 2013a-c, Ravelo 2014, and Day 2013).

The location known as the Burger Study Area within the Chukchi Sea exhibits homogeneous physical and ecological conditions and should therefore be considered as a distinct location with predictable water column, sediment composition and benthic community structure (even when considering seasonal and intra-annual variations). Specifically, the distinctive interaction between seafloor topography, persistent ocean currents, and the effects of seasonal water masses (e.g., Sections 1 and 2), as described in detail throughout this document, explains why the Burger location has a homogeneous benthic community structure and why it is physically and biologically different from more southern areas of the northeastern Chukchi Sea region.

To date, the environmental data collected in the immediate vicinity of the Burger A drill site as well as data collected from the larger Burger Study Area confirm that a benthic-dominated trophic system exists in the Burger Prospect. It can be described as a system that has less oceanic zooplankton (with presumably lower grazing capacity on phytoplankton blooms), a higher percentage of finer grained (mud) sediments (suggesting that bottom currents are not strong enough to wash away much of the mud), higher densities and biomass of benthic macrofauna and megafauna, and higher densities of benthic-feeding seals and walruses (Day et al. 2013). Due to the persistence of cold winter water, predation on benthic organisms is primarily by epibenthic invertebrates such as crabs, shrimp, brittle stars and benthic-feeding bearded seals and walruses.

As indicated by numerous discipline-specific analyses, the Burger area benthic community structure has been well characterized with respect to the local oceanographic conditions, including sediment type and composition (Weingartner et al. 2013; Blanchard et al. 2011; Blanchard et al. 2013c; Trefry et al. 2012; Blanchard and Feder 2014; and Blanchard et al. 2013a-c). Researchers associated with the COMIDA CAB project have also investigated the spatial and temporal variability in benthic community structure (composition, abundance, and biomass) and shown that it is clearly influenced by physical environmental drivers or variables such as the flow and temperature of water masses, sediment characteristics such as grain size, and food availability (Dunton et al. 2012, Konar et al. 2013; Ravelo et al. 2014) scales of sampling.

The conclusions presented in this document are based on the compilation and analysis of site characterization data from the previous five years. The data analyses, including statistical comparisons, were conducted to determine the variability within and among the data sets from the same region and to demonstrate that historical data from a larger encompassing area is sufficiently representative of conditions before drilling for impact assessment purposes. This conclusion is especially valid when it is recognized that reference or far-field sampling (i.e., control samples) for water, sediment, and biota will be an integral part of the scientific sampling protocol (Phases II, III, and IV) described in the EMP Plan of Study.

In summary, recent data demonstrate that the baseline at Burger Study Area has been characterized for the 1) initial site physical sea bottom survey; 2) physical characteristics; 3) receiving water chemistry and characteristics (with the exception of hydrocarbons, which will be included in the EMP), and 4) benthic community structure. These existing data are sufficient to serve as Phase I baseline site characterization data, as per the Permit No.: AKG-28-8100, and meet the Phase I data collection requirements.

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ATTACHMENT A

Burger A Pre-Drill Sediment Profile Imaging Survey